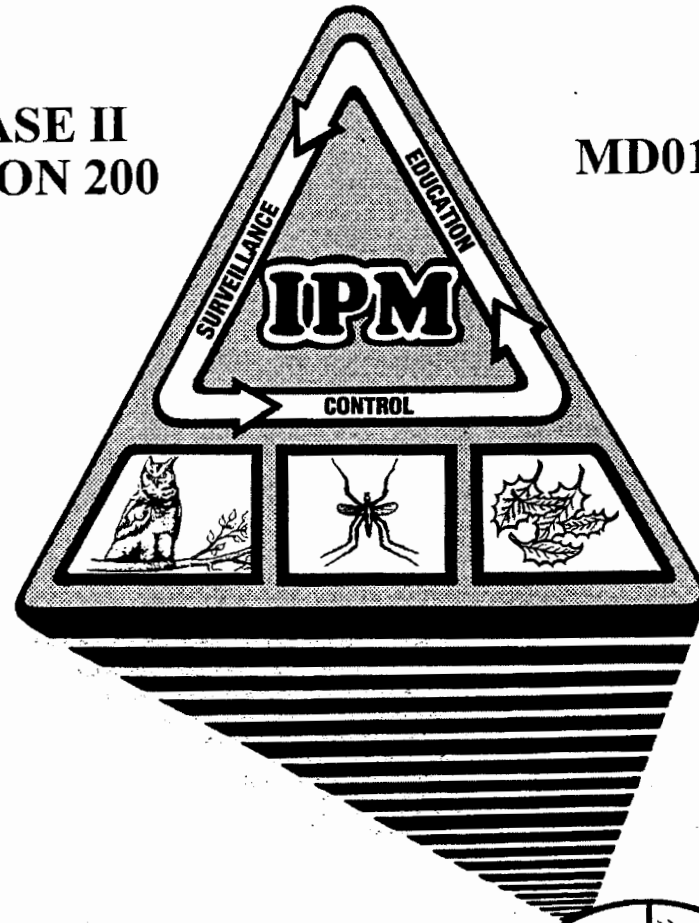
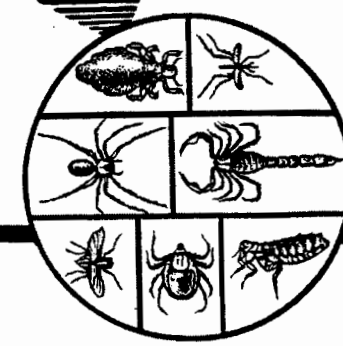
UNITED STATES ARMY
ACADEMY OF HEALTH SCIENCES

DEPARTMENT OF DEFENSE PEST MANAGEMENT COURSE

PHASE II
EDITION 200

MD0143





2002

DEVELOPMENT

This training support package (TSP) is approved for resident and correspondence course instruction. It reflects the current thought of the U.S. Army Medical Department Center and School and conforms to printed DOD doctrine as closely as currently possible. Development and progress render such doctrine continuously subject to change.

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ADMINISTRATION

For comments or questions regarding enrollment, student records, or shipment of the TSP, contact the Medical Zoology Branch at DSN 471-6801 or commercial (210) 221-6801, or send the request to the address given above.

CLARIFICATION OF TRAINING LITERATURE TERMINOLOGY

When used in this publication, words such as "he," "him," "his," and "men" are intended to include both the masculine and feminine genders unless specifically stated otherwise or when obvious in context.

USE OF PROPRIETARY NAMES

The initial letters of the names of some products are capitalized in this TSP. Such names are proprietary names; that is, brand names or trademarks. Proprietary names have been used only to make this TSP a more effective learning aid. The use of any name, proprietary or otherwise, should not be interpreted as endorsement, deprecation, or criticism of a product. Nor should such use be considered to interpret the validity of proprietary rights in a name, whether it is registered or not.

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U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL
DEPARTMENT OF DEFENSE PEST MANAGEMENT COURSE
FORT SAM HOUSTON, TEXAS 78234-6122

STUDENT INSTRUCTIONS

1. **Application for Enrollment**. Your application for enrollment in the Department of Defense Pest Management Course (DODPMC) correspondence course has been accepted.

2. **Course Design**. The DODPMC is designed as an independent study program to qualify you for the DOD Pesticide Applicators Certification under the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act, as amended, and the DOD 4150.7-P, Plan for the Certification of Pesticide Applicators. The course is not intended as a comprehensive program of study for pest management, but as qualifying instruction for certification.

3. **DODPMC Components**. The DODPMC is made up of 3 subcourses:

   MD0141, CORE Phase.
   MD0142, Phase I.
   MD0143, Phase II.

   To complete the course, you will not be required to read outside material. However, referenced materials may be of assistance to you in understanding difficult subject matter.

4. **Components of this Subcourse**.

   This subcourse consists of 17 lessons. The lessons are:

Lesson 1	Mosquito Biology.
Lesson 2	Mosquito Surveillance and Control.
Lesson 3	Biology and Identification of Flies.
Lesson 4	Filth Fly Control.
Lesson 5	Biology and Identification of Cockroaches.
Lesson 6	Cockroach Control.
Lesson 7	Biology, Identification, and Management of Lice and Fleas.
Lesson 8	Biology, Identification, and Management of Ticks and Mites.
Lesson 9	Stored Products Pests.
Lesson 10	Biology and Management of Ants and Miscellaneous Household Pests.
Lesson 11	Venomous Animals.
Lesson 12	Bird and Bat Management.
Lesson 13	Biology, Identification, and Management of Rodents.
Lesson 14	Management of Miscellaneous Vertebrate Pests.
Lesson 15	Biology of Termites.
Lesson 16	Control of Termites.
Lesson 17	Wood Destroying Organisms.

5. **Credit Awarded**. Successful completion of this subcourse qualifies eligible students for certification in the following DOD pest control categories:

   - Category 7 Industrial, Institutional, Structural, and Health-Related Pest Control.
   - Category 7a Stored Products Fumigation Pest Control.
   - Category 8 Public Health Pest Control.

QUALIFYING FOR THE DOD PESTICIDE APPLICATOR'S CERTIFICATION		
Pass the CORE exam + PHASE I exam	=	DOD Pest Control Categories 2, 3, 3a, 5, 6, and 6a.
Pass the CORE exam + PHASE II exam	=	DOD Pest Control Categories 7, 7a, and 8.
Pass the CORE exam + PHASE I exam + PHASE II exam	=	DOD Pest Control Categories 2, 3, 3a, 5, 6, 7, 7a, and 8.

6. **Lesson Materials Furnished**. Lesson materials provided include this booklet. Exercises and their solutions are contained in Appendix A of this booklet.

7. **Procedures for Subcourse Completion**.

   Step 1. Complete the subcourse lesson by lesson, reading each lesson and completing and checking the lesson exercises.

   Step 2. Notify the local Test Center that you are ready to take the final examination.

   Step 3. The Test Center will notify you that the final examination has arrived. You and that individual will coordinate a time for you to take the closed-book examination.

   Step 4. At the designated time and place, you will take the closed-book final examination.

   Step 5. Your examination sheet will be graded. Within 2 to 3 weeks, you will be notified whether you have passed or failed the examination.

8. **Examination Validity**. In order to maintain the validity of these examinations, you are not to discuss the contents of the examinations, give answers to anyone else, or reproduce the examination without permission.

9. **Course Completion/Certification**. In order to complete the course and qualify for DOD Pesticide Applicators Certification, you must achieve a minimum grade of 70 percent on each examination. You have 12 months from the time you are enrolled to complete the course. Should you require additional time, you may be granted an extension of time (a waiver) by contacting the Medical Zoology Branch, Fort Sam Houston, Texas.

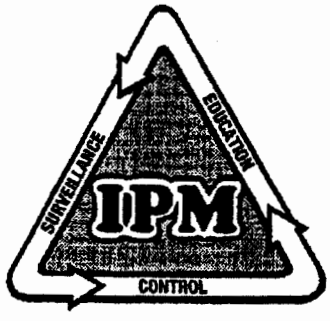
10. **Examination Failures**. Examination failures will result in one retest if you score between 50 and 69 percent. You will be given up to 90 days to retake that examination. A score of less than 50 percent or failure to retest on the CORE examination will disqualify you for the DOD Pesticide Applicators Certification by correspondence. A score less than 50 percent or failure of a retest on Phase I or Phase II examinations will disqualify you for the DOD Pesticide Applicators Certification by correspondence in the DOD pest control categories covered in the failed phase.

11. **Student Comment Sheet**. Be sure to provide us with your suggestions by filling out the Student Comment Sheet (found at the back of this booklet) and returning it with the examinations. In this way, you will help us improve the quality of this course.

12. **Study Suggestions**.

The following suggestions may be helpful to you in completing this subcourse.

- Read and study each lesson carefully.
- Complete the subcourse lesson by lesson.
- After completing each lesson, work the exercises at the end of the lesson, marking your answers in this booklet.
- After completing each set of lesson exercises, compare your answers with those on the solution sheet that follows the exercises.
- As you successfully complete each lesson of a subcourse, go on to the next.
- When you have completed all of the lessons, notify the Test Center that you are ready to take the final examination of that subcourse. Alternatively, you may wait until you have completed all of the lessons in all subcourses and request all three final examination at the same time.



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LESSON ASSIGNMENT	
LESSON 1	Mosquito Biology.
LESSON ASSIGNMENT	Paragraphs 1-1 through 1-15.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to have a basic knowledge of the biology and nature of mosquitoes IAW *AFPMB Military Pest Management Handbook*, Clements *The Biology of Mosquitoes*, Kettle, *Medical and Veterinary Entomology*, and Lane and Crosskey, *Medical Insects and Arachnids.*
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the references listed, you should be able to: 1-1. Identify the impact of mosquitoes on humans. 1-2. Identify the characteristics of each life stage of mosquitoes. 1-3. Describe the common mosquito genera and their larval habitats. 1-4. Identify the bionomic factors to consider when preparing for surveillance or control.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 1

MOSQUITO BIOLOGY

Section I. GENERAL INFORMATION

1-1. A PRIMITIVE FAMILY

The mosquitoes, or Culicidae, are a family of approximately 3,500 species within the order Diptera, the two-winged flies. They are one of the more primitive families of Diptera (suborder Nematocera). Mosquitoes are found throughout the world except in places that are permanently frozen. Three quarters of all mosquito species live in humid tropics and subtropics, where the warm moist climate is favorable for rapid development and adult survival.

1-2. IMPACT ON HUMANS

Mosquitoes are among the most serious of insect pests that have a direct impact on humans.

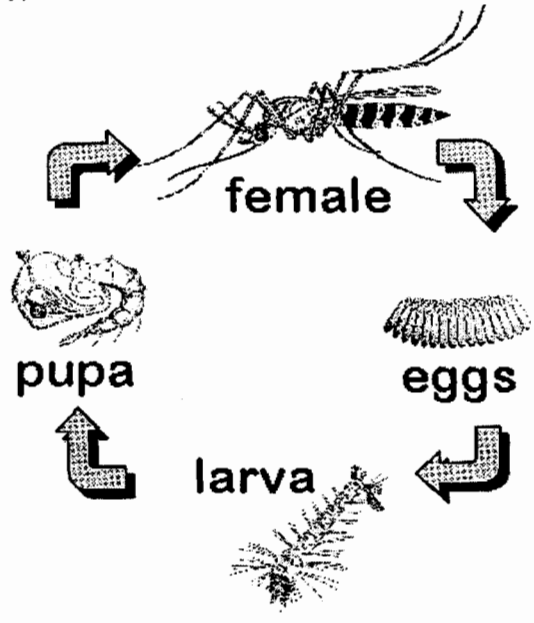
- Mosquitoes seriously affect the lives of vast numbers of people worldwide by transmitting microbial organisms that cause disease and death, including malaria, yellow fever, dengue, encephalitis, and filariasis.

- Mosquitoes may bite day or night. The larvae live in many sorts of water: fresh and brackish; foul or potable; water in tin cans, tree holes, and salt marshes.
- Large coastal areas are occasionally uninhabitable because of salt marsh mosquitoes.
- Mosquitoes can render recreation areas unusable and they often cause serious economic loss by restricting our outdoor activities.

Section II. MOSQUITO LIFE CYCLE

1-3. GENERAL INFORMATION

Like other true flies, mosquitoes exhibit complete metamorphosis, i.e. the juvenile form passes through both larval and pupal stages. The larvae are anatomically different from the adults, live in a different habitat and feed on a different type of food.



1-4. EGGS

An adult female may lay several hundred eggs at one time, depositing them directly on water or on sites that will be flooded later.

- Each egg is protected by an egg shell, which in many species is elaborately sculpted.
- The eggs of *Anopheles* and *Culex* are laid on the water, while *Aedes* and *Ochlerotatus* eggs are normally placed on damp soil or on the sides of containers which will eventually be flooded.
- Depending on the species, the eggs may be laid singly or glued together in clusters or rafts.
- Within one to two days to a week or more, depending on the temperature, the embryo develops into a fully formed larva. Many species of *Aedes, Ochlerotatus,* and *Psorophora* overwinter as eggs.
- In most species the larva hatches once it is formed, and can survive for a few days at most in the absence of water.

1-5. LARVAE

When it hatches from the egg the young mosquito larva is fully adapted for living in water, and two features determine its manner of life: use of atmospheric oxygen for respiration and use of water-borne particles as food.

- The air-breathing habit requires mosquito larvae either to live more or less permanently at the air/water interface or to make frequent visits to the water surface.
- The larvae (sometimes known as wigglers) feed on minute forms of animal and vegetable life and on decaying organic matter in the water.
- Larvae are legless, but they have a well formed head and so do not appear maggot-like.
- The growing mosquito larva molts four times. Each larval stage is called an instar.
- During the fourth molt, the larva transforms into the pupa.

1-6. PUPAE

The pupae (sometimes known as tumblers) do not feed. Though it is the "resting stage" during which the adult is formed, it is actually very active.

- The pupa rests quietly at the water surface unless disturbed, when it quickly moves to the bottom.
- It breathes through two siphons or "trumpets" on the thorax.
- When the adult is ready to emerge, the pupal skin splits along the upper surface; and the adult pulls itself up and out of the floating skin on which it then rests until ready to fly.

1-7. ADULT

Both male and female adult mosquitoes feed on the nectar of flowers, but only the female feeds on vertebrate blood.

- Body odor and carbon dioxide, carried on the wind, stimulate sense receptors on the antennae and palps of female mosquitoes, alerting them to the presence of a host.
- Adult male mosquitoes are usually found resting, feeding, or displaying behavior that is likely to bring them in contact with females.
- Upon insemination, females store sufficient sperm in their spermatheca (sperm storage organ) to fertilize a number of egg batches.
- Mosquito eggs mature in batches, following periodic blood meals by the adult female.
- When a batch of eggs have matured, the female uses chemical and visual stimuli to locate suitable oviposition sites.
- The eggs may be dropped individually to float on the water surface (eg. *Anopheles*), or packed together to form a floating egg raft, (eg., *Culex*).

Section III. GENERAL BIONOMICS OF IMPORTANT GENERA

1-8. GENERAL INFORMATION

Surveys for larval and adult mosquitoes will not be effective unless information on their biology and habits are known. A review of the general bionomics of the important mosquito genera follows.

1-9. GENUS *ANOPHELES*

Anopheline mosquitoes are distributed throughout the United States, one or more species being present in every state. (See page 1-6 for a summary of common mosquito genera.)

a. Identification.

- Most anophelines have spotted wings while most culicines (*Culex*, *Culiseta*, *Aedes, Ochlerotatus*, etc.) have clear wings.
- The females are easily distinguished from the culicines by having palpi that are about the same length as the proboscis.
- In the resting position, the adult anophelines have the head, thorax and abdomen in a straight line normally assuming an angle of from 40 degrees to 90 degrees while the culicines rest nearly parallel to the surface.
- Anopheline larvae have no siphon (air tube) and float parallel to the water surface. Culicine mosquitoes have a siphon and most genera float at approximately a 40-degree angle to the water surface.

b. Life Cycle. The eggs of anophelines are always laid singly on the water surface. They have lateral floats that keep them at the surface. Hatching occurs in 1 to 3 days and breeding is continuous during the warm seasons.

c. Habitat. Anopheline larvae are found in many different types of water although the large permanent bodies of fresh water are most common. The larvae feed just beneath the water surface where they ingest microscopic animal and plant life. Most *Anopheles* species breed in water where the higher aquatic plants are present.

d. Activity. Most adult *Anopheles* are active only at night, spending the daytime resting in dark, damp shelters.

- The peak of activity comes after dark and again just before daylight.
- All *Anopheles* apparently require a blood meal before they can lay fertile eggs.
- The species in the United States feed more commonly on the blood of domestic animals than on man.
- In most species, fertilized females overwinter.

1-10. GENUS *AEDES/OCHLEROTATUS*

Almost one-half of all North American mosquitoes belong to the *Aedes* and *Ochlerotatus* genera, which include many of the major pest species as well as important disease vectors. (See page 1-6 for a summary of common mosquito genera.) There are approximately 78 species of *Aedes* and *Ochlerotatus* in the United States, of which about 40 are common.

Until recently, *Ochlerotatus* was considered to be a subgenus of *Aedes*. It was elevated to a separate Genus in 2000.

a. Life Cycle. All species of *Aedes* and *Ochlerotatus* lay their eggs singly on the ground or above the waterline in tree holes or containers.

- Eggs hatch after flooding, and in some species, they can survive long periods of drying.
- Many of the northern species have only one brood per year. Eggs hatch after being exposed to periods of drying and cold.
- Other species are intermittent breeders, producing several generations per year depending on the rainfall or irrigation.
- All *Aedes* and *Ochlerotatus* species occurring in colder temperate regions overwinter in the egg stage.

b. Larval Habitats. Larval development sites for *Aedes* and *Ochlerotatus* are extremely variable. In general, they oviposit in temporary pools formed by rains or melting snows. Some species oviposit in coastal salt marshes that are flooded at intervals by unusually high tides. Others have become adapted to irrigation practices. A few species prefer tree holes, rock pools, and artificial containers.

c. Habits. Many species of *Aedes* and *Ochlerotatus* are vicious biters of great economic importance.

- Their biting habits are variable, but they most often attack during the evening hours.
- Some species, however, bite only during the day and others will bite either during the day or night.
- Flight ranges vary with species from one city block to over 20 miles.

1-11. GENUS *CULEX*

Several species of *Culex* mosquitoes are important disease vectors and nuisance biters. (See page 1-6 for a summary of common mosquito genera.)

a. Life Cycle. *Culex* mosquitoes deposit eggs in rafts of 100 or more each on the water surface

- Eggs typically hatch within a few days after being laid.
- Breeding continues throughout the warm season with several generations per year developing in the southern states.

b. Larval Habitats. *Culex* mosquitoes oviposit in quiet waters of almost all types from artificial containers to large, permanent bodies of water. Water in which there is considerable organic material including sewage is often favored.

c. Habits.

- Adult females usually feed at night and remain inactive during the day.
- Their flight range is typically limited to only a few miles.

1-12. GENUS *CULISETA*

Members of this genus are somewhat similar in appearance and habits to *Culex*. There are eight species in the United States of which five are fairly widespread. They are relatively unimportant as pests. Some have been found naturally infected with encephalitis virus but their relation to the epidemiology of these diseases is not well understood.

1-13. GENUS *PSOROPHORA*

Fourteen species of *Psorophora* are known from the United States. While they are not common vectors of human disease, some of the species are extremely aggressive biters.

- The breeding habits of this group are similar to those of the typical *Aedes* and *Ochlerotatus* species, to which they are closely related.
- The eggs are laid on the ground and are adapted to withstand drying.
- The eggs may lie dormant for months or years. After flooding, they hatch quickly and the development of the larvae is very rapid.

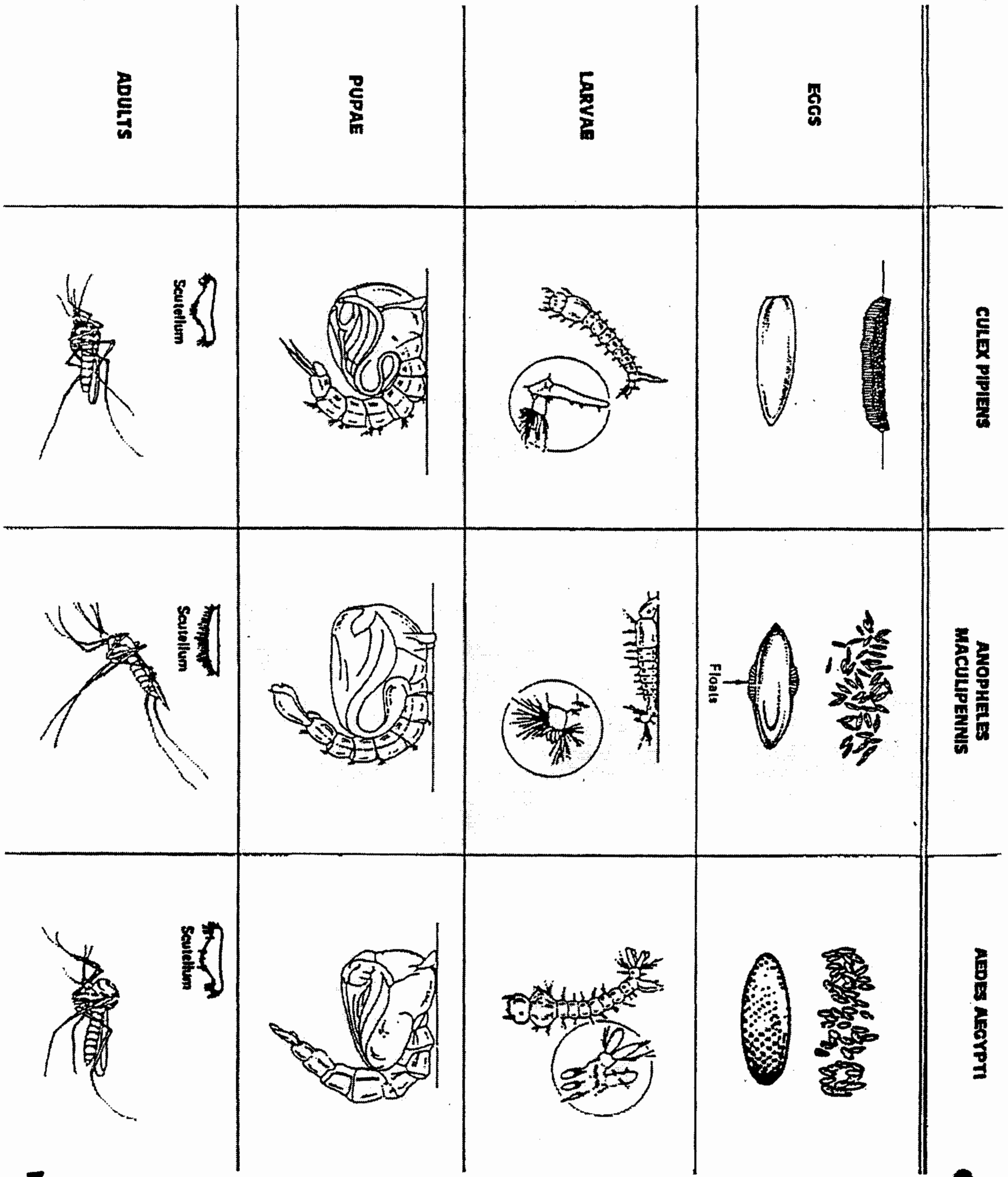
1-14. GENERA *MANSONIA* AND *COQUILLETIDIA*.

These generally include three species in the United States, one of which is very widespread and common. They are troublesome biters and severe pests in many areas.

- Their eggs are laid in rafts on marshes or lakes.
- After hatching, the larvae descend below the surface of the water and insert their air tubes into the stems or roots of aquatic plants.
- They remain below the water surface throughout the larval and pupal stages obtaining air from these plants. Because of this unique habit, larvae cannot be controlled by use of surface larvicides.

1-15. OTHER GENERA

- There are four species of ***Uranotaenia*** in the U.S. They oviposit in ground pools, the grassy margins of lakes, and occasionally in tree holes and potholes.
- ***Othopodomyia*** are highly ornamented species that oviposit in tree holes and in water in leaf bases or bromeliads. Sometimes they breed in large numbers in artificial containers when abundant organic matter is present.
- The ***Toxorhynchites*** are large, brilliantly colored, non-bloodsucking mosquitoes. The huge, clumsy larvae prey upon other mosquito larvae in tires, tree holes, bromeliads, and other water-holding containers.
- Four species of ***Wyeomyia*** oviposit in small collections of water in the leaves of pitcher plants, in other living or dead plants, and in tree holes. Several species have been successfully used as biocontrol agents against nuisance mosquitoes.
- ***Dienocerites*** are found breeding in salt water in crab holes in Southern Florida and Texas.



A Summary of Common Mosquito Genera.

EXERCISES, LESSON 1

REQUIREMENT. Answer the following exercises by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. List three diseases transmitted by mosquitoes.

   a. _____

   b. _____

   c. _____

2. List the two features that determine the mosquito larva's manner of life.

   a. _____

   _____

   b. _____

   _____

3. What occurs during the pupal stage of development, and how do pupae behave

   _____

   _____

4. The adult female mosquito feeds on:

   a. _____

   b. _____

5. What is the flight range for species in the genera *Aedes and Ochlerotatus*?

   _____

6. a. *Anopheles* larvae are most often found in _____ water.

   b. When are the peak biting periods for most *Anopheles* mosquitoes?

   _____

   _____

7. A favored oviposition site of the _____ mosquito is in water containing considerable organic material including sewage.

8. Why can't *Mansonia* larvae be controlled by the use of ordinary surface larvicides?

   _____

   _____

   _____

9. The _____ mosquitoes are highly ornamented and sometimes oviposit in large numbers in artificial containers when a large amount of organic matter is present.

10. The _____ mosquitoes oviposit in salt water in crab holes in southern Florida and Texas.

Go to Appendix A to check your answers.

LESSON ASSIGNMENT	
LESSON 2	Mosquito Surveillance and Control.
LESSON ASSIGNMENT	Paragraphs 2-1 through 2-15.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to employ the principles of integrated pest management against mosquitoes IAW TB MED 561, *Occupational and Environmental Health Pest Surveillance* and AFPMB *Military Pest Management Handbook*.
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the references listed above, you should be able to: 2-1. Identify the essential reasons for conducting mosquito surveillance. 2-2. Identify the appropriate sites for mosquito surveillance. 2-3. Describe the surveillance methods used for mosquitoes in each life stage. 2-4. Identify the reasons for integrating mosquito population index data into a mosquito control program.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 2

MOSQUITO SURVEILLANCE AND CONTROL

Section I. GENERAL INFORMATION

2-1. INTRODUCTION

Mosquitoes probably have a greater influence on human health and wellbeing throughout the world than any other arthropod, because of the important diseases they transmit and the annoyance they cause. In the United States, the primary reason for controlling mosquitoes is to lessen the annoyance caused by their bites and to reduce the transmission of viral encephalitis and dog heartworm.

2-2. THE NEED FOR SURVEYS

Whether pest managers are aligned with a medical or engineering organization, it's essential to conduct mosquito surveys to determine the species present, their abundance, their potential as disease vectors, and to collect enough information on which to base a pest management program. Surveys should be a continuing part of the pest management program.

- Survey results assist pest managers anticipate increases or decreases in operations relative to changing mosquito populations. They provide a relative historical record of mosquito populations.

- Surveys are used to evaluate the effectiveness of pest management actions.

- To adequately conduct mosquito surveys, the first thing needed is a map of the survey area. Use it to become familiar with the area, locate larval development sites and establish good sites for sampling stations.

NOTE: In addition to the survey methods discussed below, there are a number of special procedures occasionally used in research or special disease survey programs.

2-3. LARVAL SURVEYS

Larval surveys show the exact areas where mosquitoes are developing, so they have special value in guiding mosquito management operations.

- Identify and mark the map for regular larval dipping stations, then inspect them periodically throughout the breeding season.

- Conduct random larval sampling in the control area to check the effectiveness of larviciding.

- Larval stations may be barrels, small pools, ditches, drains, ponds or almost any type of water container.

- If possible, use a white enamel or plastic dipper to collect survey samples, then record findings as the number of larvae per dip. Specimens can be transported in watertight containers for later identification.

- Use large-mouth pipettes, turkey basters, or siphons to collect samples from small areas such as tree holes or tires.

2-4. ADULT SURVEYS

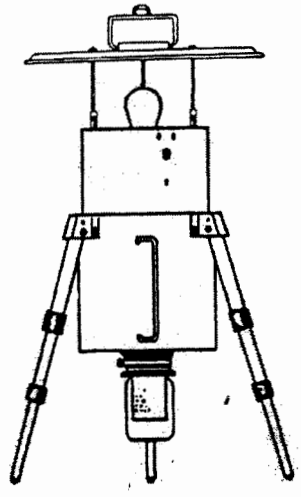
Several methods are available to conduct adult mosquito surveys, including traps and resting stations as well as biting and/or landing rates.

- The methods used in a particular situation will depend upon the habits of the species concerned.

- Use a combination of methods whenever possible, particularly where there are several species with different behavioral characteristics.

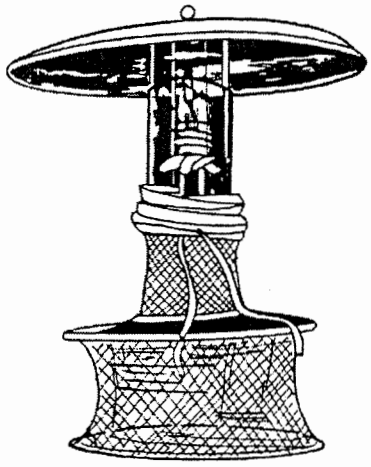
2-5. ADULT SURVEYS - LIGHT TRAPS

The "New Jersey" light trap is a large, durable trap. This trap is constructed of an aluminum cylinder approximately 18 inches in diameter and 3 feet tall. The trap is weather proof and is normally left in place for the duration of the mosquito season. There is often a 24-hour timer that automatically turns the trap on and shuts it off. The limitations of the New Jersey light trap are its large size and that it must be connected to a permanent electricity supply.



a. Description. More recently, the CDC or Solid State Army Miniature (SSAM) light trap has replaced the New Jersey design as the mosquito trap used on many military installations, and it is commonly used in field operations. The SSAM light trap functions very similarly to the New

Jersey light trap, but is collapsible. Both of these traps provide a relative index of abundance for most species. The addition of carbon dioxide (as dry ice) greatly increases the efficiency of traps.



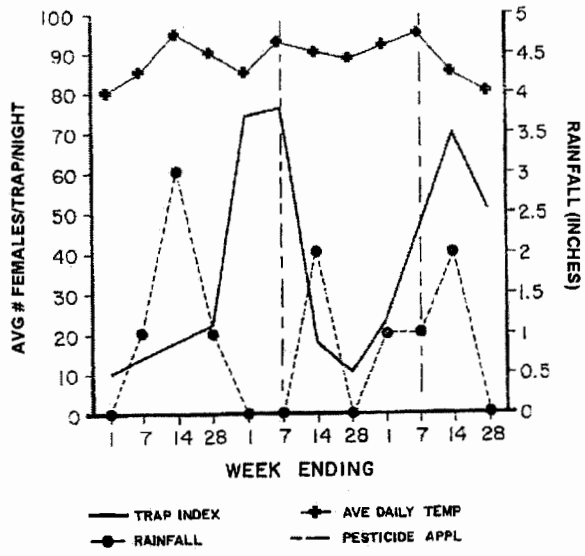
Note: **Some *Anopheles* and *Aedes* are poorly (or not at all) attracted to light, so light traps cannot be used to survey them.**

b. Placement/Operation. Whenever possible, place light traps six feet above ground where they are sheltered from wind as much as possible and far away from other artificial light sources.

- Ideal locations are between the installation garrison area and larval development sites.
- Consistently use the same type and size bulb to obtain a standard index for seasonal or locality comparisons.
- Operate traps one to four nights a week unless the main purpose is to detect uncommon species. In this case, operate them every night.
- Always operate traps from dusk to dawn.
- Remove the contents as soon as possible each morning following collections to avoid excessive damage to specimens.

c. Mosquito Collections. Sort collections according to species and sex, and record the numbers taken at each station.

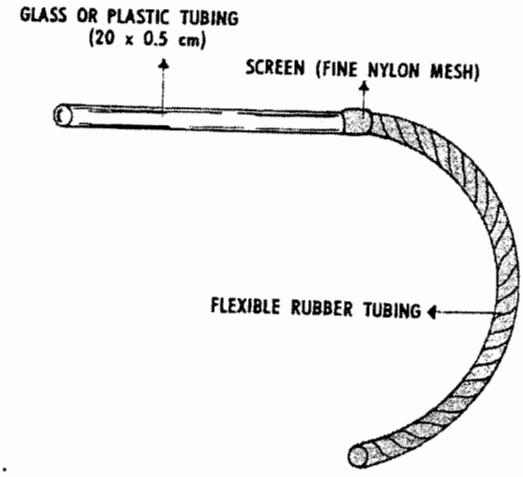
- A common index is the number of female mosquitoes caught per trap night (described in Section 2-10).
- Average the weekly index for several stations to give a composite index for a particular area or installation.
- The weekly trap index is also used to plot a graph to show mosquito population changes (either naturally or resulting from control measures) on seasonal and annual variations. This graph shows temperature and rainfall patterns as well as timing of insecticide application.



- Rainfall and temperature figures are useful to determine when to start or stop control operations when such figures are plotted along with the trap index for past years.
- Control dates should always be plotted on the graph.

2-6. ADULT SURVEYS – LANDING OR BITING RATES

Collecting mosquitoes with an aspirator as they land on or bite a person or animal is a simple way to determine the important pest species and estimate their relative abundance.



SIMPLE ASPIRATOR

- Don't use the aspirator method in areas where disease transmission is known to exist unless the subject is adequately protected from the potential of becoming infected and there is a compelling reason for conducting this type of surveillance.

- Standardize the method used as to timing, the person or animal used, and locations in order to make comparisons between the biting rates that occur at different locations.

- Sample regular stations at intervals of one to two weeks and collect mosquitoes with an aspirator for a designated period of time (usually 10-15 minutes) from a standard area such as the back or from both legs of the subject.

- Convert the number of each species collected to landings or bites per hour to obtain a standard index.

- When populations are very high, this method is useful for a rapid check of mosquito abundance before and after treatment.

2-7. ADULT SURVEYS - RESTING STATIONS

Adults of many species are inactive during the day; they're easily found resting quietly in cool, dark, and damp places.

- To prepare a population density index, conduct counts in a standard way for equal time periods so records of one inspection will be comparable with those made at the same station on other days.

- Use an aspirator to make collections in houses, stables, sheds, culverts, and similar shelters to get a good indication of mosquito species in the area.

2-8. ADULT SURVEYS - ANIMAL BAIT STATIONS

Animal bait stations are excellent devices for collecting mosquitoes during disease outbreaks or for long-term research.

- These stations may be made large enough for a horse or small enough for small cage animals such as raccoons.

- Such devices can be made of cloth, but normally are best constructed of wood.

- They should be constructed so mosquitoes can enter through an opening on each side.

- Make these openings somewhat funnel shaped with a much smaller opening on the interior of the trap; this makes it easy for mosquitoes to enter, but difficult to escape.

- The trap must have an opening large enough for an individual to enter, close the door, and then collect resting adult mosquitoes.

Section II. SURVEILLANCE DATA, CONTROL RECOMMENDATIONS, AND IMPORTANT SPECIES

2-9. INFORMATION FROM DATA

The data obtained from mosquito surveys must be properly compiled and correlated to provide meaningful information. Proper interpretation and translation of this information into action will save manpower, materials and equipment, and furnish justification for an entire operation.

2-10. RECORDING SURVEILLANCE DATA

a. Determine Need/Effectiveness of Control Measures. Compare the abundance of mosquitoes with historical data to determine the need for and to document the effectiveness of control measures. Record and maintain the data from mosquito surveillance activities for permanent documentation to ensure continuity of the mosquito surveillance effort.

b. Record Data. Maintain the data in accordance with service specific requirements (eg., DA Form 8011-R Mosquito Surveillance Light Trap Collections and DA Form 8012-R Mosquito Surveillance Larval Collections).

- Number, sex, species, and date collected at each site and trap.
- Weather data, such as daily high and low temperature, rainfall, and wind speed and direction.
- Pesticide treatment data, such as date, pesticide used, rate, method of application, and area(s) treated.

c. Adult Mosquito Index. An adult mosquito index is usually calculated to average several collection sites or traps to provide a composite index for a particular area or installation. One index commonly used for light trap collections is "females per trap night." The equation is:

$$\text{Index} = \frac{\text{\# of adult females}}{(\text{\# of Traps})\,(\text{\# of Nights})}$$

Similar indices can be calculated for other collection methods.

d. Graph the Data. Plot the data as a graph to help visualize changes in the mosquito population and detect long-term trends. This plot can show the effect of rainfall and temperature on mosquito populations and the effectiveness of pesticide applications.

2-11. GENERAL INFORMATION ON CONTROL

a. PVNTMED Responsibility. Preventive medicine/public health personnel at the installation hospital or clinic are responsible for mosquito surveillance. When results of these surveys indicate that control is required, personnel notify the appropriate installation activity, usually the Installation Pest Management Coordinator (IPMC). The recommendation for mosquito control is usually made when an index for one or more surveillance techniques exceeds a threshold level. Mosquito control may also be deemed appropriate by other indicators (for examples, human or animal disease outbreaks, potential disease outbreaks, and complaints).

b. Determine the Need for Pest Control Measures. An effective surveillance program must include a way to determine the need for pest control measures. The presence of a pest does not automatically mean a recommendation to the IPMC for control. Thresholds are established to help predict when control measures are needed.

(1) Threshold value. The threshold value is used to protect personnel or property from the pest by initiating control measures before a pest problem occurs.

- For example, at a particular installation it has been established that mosquito annoyance complaints are received when the trap index exceeds 20. In this case, the threshold is established at 20 so that control measures may be initiated in a timely manner.

- Establish thresholds to prevent disease transmission, complaints, and damage.
- Threshold values will vary at each installation depending on factors such as species, area involved, habitat, collection technique, number of complaints, and disease potential.

(2) Use caution. Thresholds are only indicators and therefore should not be the only factor used in the decision to recommend control measures.

c. Recommend Several Pest Control Methods. Installations should not rely exclusively on pesticide application for mosquito control. Make recommendations to the IPMC for non-chemical as well as chemical measures. Non-chemical measures include:

- Improve natural drainage in ditches, streams, and borrow pits.
- Improve natural drainage in areas that flood during heavy rains.
- Eliminate artificial containers.
- Control aquatic vegetation.
- Clear blocked culverts.

d. Individual Protective Measures. In areas where control is impractical or prohibited, preventive medicine/public health personnel initiate or intensify training concerning protective measures as needed. These measures include:

- Limiting exposure of skin by wearing a long-sleeved shirt with sleeves worn rolled down.
- Wearing a hat.
- Blousing trousers into boot tops.
- Wearing headnets.
- Using repellents.
- Using bednets.
- If possible, limiting exposure by not entering infested areas or not being outside during biting activity periods.

Section III. MOSQUITO ABATEMENT (MANAGEMENT)

2-12. GENERAL INFORMATION

Mosquito abatement methods may be either long term or temporary programs directed against larvae or adults. Larval management includes using larvicides and eliminating breeding sources by improving water drainage or using other methods of water management. Managing adults may involve applying aerosol insecticides, fogs, and sprays over infested areas, using residual sprays, quick knockdown treatments, chemical barriers, and/or personal protection methods such as screens, nets, and repellents.

2-13. LONG-TERM METHODS

Long-term abatement methods focus on controlling water where mosquito larvae develop.

- **Methods and time.** Ditching, pumping, filling and similar measures can take large amounts of time, labor, and equipment to give long-term results.
- **Cost.** Their high initial cost, both to implement and to maintain equipment, must be weighed against the cost of temporary measures, such as insecticide application, on a scheduled and continuing basis, but results are much more effective and permanent when conducted properly.
- **Wetland modification.** Do not begin long-term measures without first obtaining assistance from the installation environmental office in reviewing the laws and regulations regarding wetland modification.

a. Stream and Pond Management. The following methods are all viable mosquito control methods. However, before any modifications are made to wetland areas you MUST consult your local environmental office to obtain the correct permits prior to doing modifications.

(1) Improving natural draining. Shallow sluggish streams and ponds containing plant growth provide excellent conditions for mosquito breeding.

- Increase the water flow rate and reduce its surface area to decrease mosquito breeding; this is often less expensive than other methods.
- Obtain instruction from maintenance engineers to plan and carry out this operation.

(2) Stream flushing. Where existing drainage control includes small dams, it may be possible to use these systems for mosquito abatement.

- To do this periodically release collected water, either manually or by automatic siphon, to flush the stream below the dam.
- The stream must have sufficient capacity to prevent it from flooding over its banks.
- It can be very effective if it is possible to flush a stream at shorter intervals than it takes for the mosquitoes to complete their aquatic development.

(3) Impounded water. Mosquito abatement in impounded water depends on reservoir preparation, water level fluctuation and proper shoreline maintenance.

- Clear reservoirs to provide a clean water surface after impoundment between maximum and minimum water levels.
- Fill or alter depressions between minimum and maximum water levels to drain during water level fluctuations of the lake or pond.
- Accomplish winter impounding after the normal breeding season ends. Lower the water level at intervals not to exceed 10 days to strand eggs, larvae and pupae at the margin, strand protective debris, and expose larvae to predators.
- Changes to water levels may involve a cyclical fluctuation, a seasonal recession, or a combination of these methods.
- Shoreline drainage, removing, and burning driftwood, and controlling growth of shoreline vegetation should all be a part of this action so water level fluctuation will not cause an increased breeding area for another pest species.

b. Managing Aquatic Vegetation. Aquatic vegetation protects mosquito larvae and pupae from wave action, natural enemies and, in some cases, may seriously interfere with larvicide applications on the water surface.

- If such vegetation is a serious problem, its elimination becomes an essential part of mosquito abatement.
- Either chemical or mechanical removal may be the proper procedure, depending on the type of vegetation, size of area, and how the water is used.
- Consider soil erosion and the effects of any vegetation management techniques on fish and wildlife.

c. Coastal Marshes. To manage mosquitoes in these areas, alter the salt content of water in the marsh, or use dikes and tide gates designed to control flooding.

- Planners need a thorough knowledge of the species and habits of the mosquitoes present to effectively conduct this type of management.
- Salt content in the water may seriously affect or limit the breeding of some species. **Warning**: Many other aquatic/marine species may be affected as well.
- Opening channels to let sea water enter breeding areas, or excluding sea water to reduce salt content may significantly reduce mosquito breeding.

- Use tide gates to prevent salt water from leaking in natural watercourses or ditches.
- Two or more gates are sometimes used side by side.
- Install breakwaters and spearheads to prevent sand from blocking outfalls.

d. Fish. Surface feeding fish are sometimes used as a supplementary control measure against mosquito larvae.

- The most useful are top minnows (*Gambusia*, *Labistes*, and *Panchax* spp.) in permanent fresh water and killifish (such as *Cynolebias bellotii*) in temporary freshwater pools.
- Of these, only *Gambusia* spp. are used in the continental United States. Killifish have been used with moderate success in field trials in California.
- Remove marginal aquatic plants to help fish catch mosquito larvae more easily.

e. Pumping. Use pumps to drain water when the area to be drained is at or below the water level of an adjacent body of water. Several standing pools may be drained into one, and the water pumped from this pool to the selected outfall.

f. Filling and Grading. Fill and grade shallow pools to prevent mosquitoes from breeding in such places as beneath buildings, on improved grounds, or beside roadways.

- Filling may reclaim valuable land areas, as well as eliminate mosquito breeding.
- If hydraulic filling is recommended, take care not to block natural drainage.
- Cracks and low areas are likely to form as the fill settles, and will afford breeding places when flooded; pest managers can effectively treat these areas with mosquito larvicides.

g. Ditching. Adequate ditching should remove water so ground surfaces become dry and ditch levels return to normal within 4-7 days (depending on climate and mosquito species) after the ditch is filled by heavy rainfall or irrigation.

- Soil texture, topography, vegetation, rainfall, and tidal movement in salt marshes, are important factors.
- In designing drainage systems, care is needed to prevent creating mosquito breeding areas in new locations.

2-14. TEMPORARY METHODS

Larvicides and adulticides are the most important temporary mosquito abatement methods. Pest managers should use such temporary measures to give immediate relief from mosquitoes and when more permanent measures are lacking or in planning.

- Temporary methods are often much less costly than permanent measures, at least initially. In some instances, they may be used at less expense than permanent systems, provided they do not adversely effect people or the environment.
- It is often vital to take such temporary methods to rapidly reduce disease vectors during an arthropod-borne disease epidemic or during short-term operations in an endemic disease area.

a. Larval Management. To temporarily manage mosquito development sites, treat water surfaces with insecticides, or eliminate small water accumulations in temporary containers. Breeding areas include most types of ground water accumulations, as well as containers such as tin cans, cisterns, wells, reservoirs, fires, barrels, roof gutters, tires, catch basins, etc. All such water-holding containers must be treated to achieve effective management.

(1) Pesticide formulations used. Larviciding is done with many pesticide formulations. Solutions, emulsions, suspensions, dusts or granules may be applied with ground-operated equipment. Use granular formulations where heavy plant cover must be penetrated.

(2) Breeding containers. Containers such as empty tin cans and old tires, in which mosquitoes may breed, should be eliminated as much as possible. Treat those that can not be eliminated with a larvicide to prevent

breeding. Solicit the help of all people in the area to eliminate temporary water containers.

b. Adult Control. Adult mosquitoes are effectively managed with residual chemicals and space sprays. Adequately screening occupied structures is also essential where mosquitoes occur.

(1) Indoors. Use space sprays to manage mosquitoes indoors where immediate reduction is needed. These sprays have little or no residual effect and must be reapplied whenever new mosquitoes enter the area.

- Where frequent reentry is a problem, or where disease-bearing species are present, apply residuals to all surfaces where mosquitoes are likely to rest (unless otherwise prohibited, such as in a food service area or hospital).
- Treat surfaces such as door and window screens, walls, corners, chest interiors, etc.
- Screens with apertures equivalent to 18 x 16 mesh are essential to keep disease-bearing and pest mosquitoes, flies, and other insects from entering buildings.

(2) Outdoors. Use Ultra Low Volume (ULV) space treatments to manage adult mosquitoes outdoors. These treatments can't completely eradicate mosquitoes in the target area, but commonly give adequate protection for a day or more.

- In areas where breeding is continuous or the population is dominated by migratory species, ULV space sprays alone are seldom satisfactory unless done on a repetitive basis.
- Such repetitive treatments are usually very expensive and pose some risk to people or the environment. Avoid them except in the most unusual conditions and consult the command entomologist before starting such repetitive treatments.
- When properly applied on a non-repetitive schedule, ULV space treatments will leave a small residual deposit that is not dangerous or unsightly.
- Exterior residual sprays have a limited value in protecting single residences or small camps.
- For larger areas where ULV treatments are not possible, apply a residual spray to vegetation surfaces within a radius of 100 feet or more around the site to kill mosquitoes resting in the vegetation.

2-15. CONTINGENCY CONSIDERATIONS

Mosquitoes are generally the most important arthropods managed in contingency operations because of the number, types, and distribution of diseases they transmit. A historical review of all the conflicts fought in Asia, Africa, Central America, and South America clearly demonstrates the adverse impact of these insects on the ability of military forces to carry out their battlefield mission or operations other than war missions. These actions are essential. To effectively combat such mosquito-borne diseases, the following actions are essential:

a. Individual Protective Measures. These are those measures all military personnel must take to protect themselves.

- Use skin-applied repellents, insect repellent mesh jackets, permethrin treated uniforms, bednets, limited amounts of aerosol space sprays, and headnets in extreme cases.
- For additional protection, wear uniforms with sleeves rolled down and buttoned and pants tucked into the boots.
- In areas where malaria is endemic, preventive drug treatments (chemoprophylaxis) should be started before deployment and rigidly enforced during deployment in the area and for a prescribed period of time after leaving the area as directed by the command surgeon or preventive medicine officer.

b. Unit Protective Measures. In addition to the above individual actions, a unit can carry out additional measures when it's operational overseas or during contingency operations to reduce the potential for arthropod-borne disease transmission. The main unit effort should focus on training people in protective measures and then strictly enforcing them,

especially the regular use of malaria chemoprophylaxis as directed by the command surgeon or preventive medicine officer.

c. Area Protective Measures. Area protective measures are those carried out by preventive medicine or engineering units with specially trained technicians using special equipment and controlled or restricted-use pesticides. These are the only military units with the equipment and training needed to conduct a large-scale pest management operation.

EXERCISES, LESSON 2

REQUIREMENT. Answer the following exercises by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. List four reasons for conducting mosquito surveys.

   a. _____

   b. _____

   c. _____

   d. _____

2. What is the value of a larval survey?

   _____
   _____

3. Light traps are often not effective in surveying *Aedes* adult mosquitoes because

   _____

4. a. Light traps should be operated _____ times per week when surveying common species of mosquitoes.

   b. The time period for the operation of the traps is _____.

5. You are using light traps to survey the adult mosquito population. How do you obtain the composite index for an installation?

_____

_____

6. During disease outbreaks or for long-term research, _____ are outstanding devices for collecting mosquitoes.

7. What is the focus of long-term methods for controlling mosquitoes? _____

_____

_____

8. List three long-term methods for controlling mosquito development sites using stream and pond management.

a. _____

b. _____

c. _____

9. When planning management of aquatic vegetation, consider the following;

a. _____

b. _____

c. _____

10. The most important temporary mosquito abatement methods are:

a. _____

b. _____

Go to Appendix A to check your answers.

LESSON ASSIGNMENT

LESSON 3	Biology and Identification of Flies.
LESSON ASSIGNMENT	Paragraphs 3-1 through 3-11.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to identify common flies and their natural history IAW AFPMB *Military Pest Management Handbook* and TIM 30 Filth Flies.
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the references listed above, you should be able to: 3-1. Identify why flies are important to man. 3-2. Identify the key characteristics in the life cycle, habitat, and diseases of the flies described. 3-3 Identify diseases that can be transmitted by flies and the specific vectors for each disease.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 3

BIOLOGY AND IDENTIFICATION OF FLIES

Section I. BIOLOGY OF FLIES

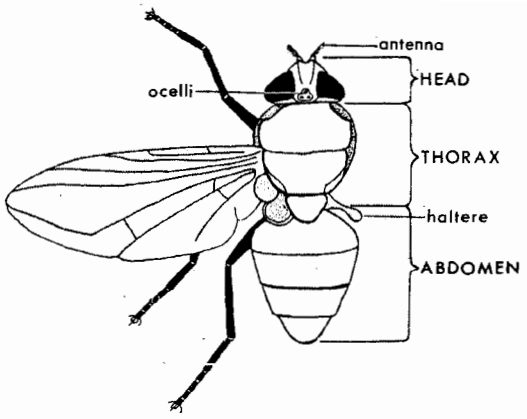
3-1. INTRODUCTION

Flies have been intimate companions of humans for eons. Flies can be conveniently categorized as filth flies or biting flies. Both may have a negative impact on humans.

- Filth flies potentially spread food- and water-borne pathogens responsible for diarrheal diseases such as *salmonella*, *shigella*, and cholera.
- Fly larvae infest human and animal flesh, and attack and destroy crops.
- Some biting flies have painful or irritating bites and may also transmit human disease such as African sleeping sickness, onchocerciasis, and leishmaniasis.
- In some regions, flies are such abundant nuisances that morale and operations capabilities are degraded.

3-2. BIOLOGY OF FLIES

True flies are in the order Diptera. This is one of the largest orders of insects, totaling more than 110,000 species. Adult Diptera are typically identified by the following characteristics:



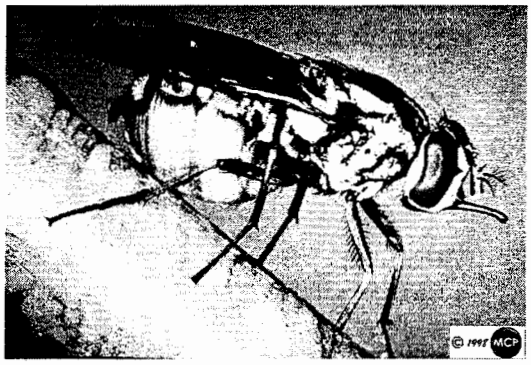
- One pair of wings and halteres (knob-like structures behind the wings that function as balancing organs). Some species may not have halteres.
- Like all insects, adult flies have three body regions: head, thorax, and abdomen.
- Most flies have very large compound eyes that take up a large area on the outer surface of the head.
- Mouthparts may be either sponging, rasping or piercing and sucking.
- Flies (except Nematocera) have antennae with three segments. These may appear fused apically or sub-divided into apparent segments.
- Flies undergo complete metamorphosis.

Section II. BIONOMICS OF BITING FLIES

3-3. GENERAL INFORMATION

Biting flies are those which most commonly cause problems at military installations. They may be disease vectors or annoying pests to people and domestic animals. All flies discussed in this section have one characteristic in common - they need blood for food.

3-4. STABLE OR DOG FLY (*STOMOXYS CALCITRANS*)



The stable fly is worldwide in distribution and is a serious pest to people and domestic animals wherever it's found. It's a member of the family Muscidae.

a. Identification. The stable fly is often called the "biting house fly" because it strongly resembles the house fly in appearance. However, it's easily distinguished from the house fly by its sharp, piercing, forward projecting, non-retractile proboscis. Both sexes bite.

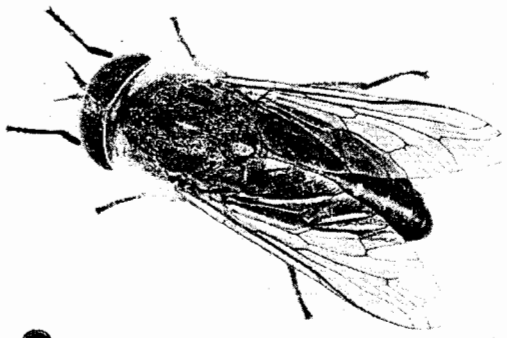
b. Life Cycle. Like many domestic flies, females lay their eggs in moist, rotting, or fermenting organic material such as marine grass, straw, grain wastes, grass cuttings, and urine soaked straw. Decaying seaweed is an ideal larval development site on many southern U.S. beaches.

- One female oviposits up to 50 eggs at a time and can lay several batches in her lifetime.
- Eggs hatch in 2-5 days, depending on air and media temperature. Larvae develop in 11-20 days are followed by a pupal period of 6-20 days.

c. Disease Transmission. There is no documentation that the stable fly is a biological vector of human disease, but it does transmit Surra (a trypanosomal disease of horses and mules) and infectious anemia (a viral disease of horses). It is primarily important because it is a vicious biter and blood feeder.

-ATTENTION-
This fly's uncontrolled presence can cause military units to become temporarily incapacitated by its annoyance and has caused temporary closing at some beaches and recreation areas.

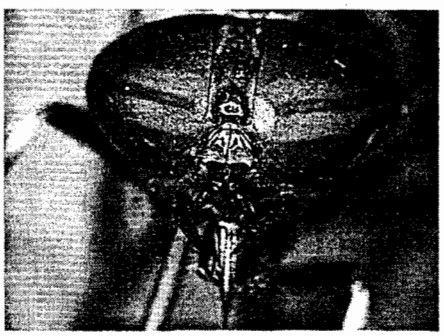
3-5. HORSEFLIES AND DEERFLIES (FAMILY TABANIDAE)



Horseflies and deerflies are in the family Tabanidae which includes more than 3000 species, 300 of which are found in North America.

a. Identification.

- Members of this family of flies are stout, practically without bristles, and are strong, swift flyers.
- Many horseflies are large, some with a wing span exceeding 2 inches, but deerflies are only slightly larger than the house fly.
- Most have large, prominent, brilliantly colored eyes, and large hemispherical heads.



- All have short, protruding antennae.

b. Life Cycle. A female will lay several hundred eggs, on leaves of aquatic plants or vegetation bordering bodies of water.

- The eggs hatch in about seven days and the emerging larvae drop into the water or onto the damp soil at the edge of the water.
- Larvae spend one to three years in this developmental stage, living in mud or damp moss and feeding on small animal life.
- There are also species adapted to upland habitants, species that do not require water or saturated soil.
- When their development is complete, the larvae migrate to drier ground to pupate.
- The adults emerge in two to three weeks.

c. Disease Transmission. In addition to inflicting painful bites which may also result in substantial blood loss to domestic animals, the tabanids are vector several human diseases. Deerflies transmit diseases such as *Loa loa*, or "eye worm," and tularemia.

3-6. BLACK FLIES (FAMILY SIMULIIDAE)

There are more than 1300 known species of black flies (or buffalo gnats) in the Family Simuliidae. Their range extends throughout the temperate and tropical regions of the world.

a. Identification. These are small, stout, black or gray flies (1-6 millimeters) with broad wings.

- The thorax has a characteristic "humped" appearance.

- Their wings are relatively short, broad, and clear.
- Antennae are short and composed of beadlike sub-segments (moniliform)
- Their mouthparts are adapted for piercing and sucking.

b. Life Cycle. Females lay up to 500 small yellow eggs at one time, usually placing them on stones or plants trailing in fast moving streams.

- Eggs hatch in 4 to 12 days, and the larvae attach themselves to stones or plants in the stream by means of adhesive anal disks and tiny hooks on the abdomen.
- Pupation occurs after 6-7 larval molts and adults emerge from the pupal cases within a week.

c. Disease Transmission. Several species vector onchocerciasis ("river blindness").

d. Nuisance. These flies are extremely important as biting pests.

- Their puncture and actual feeding may be painful.
- When the fly has fed, the puncture site is marked by a slight trickle of blood from the wound.
- Within an hour a welt about the size of a dime appears and intense itching begins and may last for several days.
- Because these flies are small and people do not initially feel a bite, they may suffer many bites before realizing it. Such cases may require medical attention.

3-7. SAND FLIES (*PHLEBOTOMUS* AND *LUTZOMYIA* SPP.)

Several groups of flies throughout the world are commonly known as sand flies. True sand flies are in the family *Psychodidae*.

a. Identification. These flies are seldom larger than 5 millimeters long.

- Sandflies are easily recognized by the position of the wings that are elevated and spread to form a "V".
- The wings and body are densely covered with hairs.
- Antennae are long and slender, having 12 to 16 sub-segments.
- The mouthparts are long and adapted for bloodsucking.

b. Life Cycle. The female may lay several batches of eggs, but must take a blood meal before each one.

- She lays her eggs in cracks in soil or stones.
- When the eggs hatch, four larval instars follow, with pupation occurring in the last stage.
- The entire life cycle takes 1 to 4 months.

c. Disease Transmission. Sand flies vector various diseases in many areas of the world.

- Phlebotomus fever (sand fly fever or Pappataci fever) is found in the

Mediterranean area and in India, Burma, China, Ceylon, South America, and East Africa.

- Bartonellosis (Oroya fever) is transmitted by several species of *Lutzomyia* in South America.

- Visceral leishmaniasis (kala-azar), muco-cutaneous leishmaniasis, and cutaneous leishmaniasis (Oriental sore) are other diseases sand flies transmit to humans in broad geographic areas where U.S. military forces operate.

3-8. BITING MIDGES OR PUNKIES (*CULICOIDES* SPP.)

A group of blood-sucking flies commonly called "punkies," "no-see-ums," or "salt-marsh sand flies," is one of several genera in the family Ceratopogonidae.

a. Identification. These extremely small flies can easily pass through window screens and standard mosquito netting.

- Their wings often have patterns of dark and light areas which give the fly a speckled appearance.

- Mouthparts are adapted for piercing and sucking.

b. Life Cycle. A female may lay as many as 100 eggs on damp sand or soil.

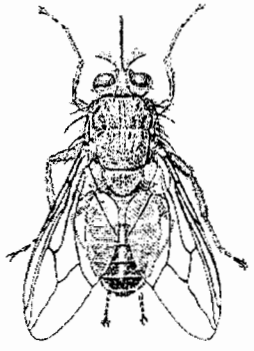
- These hatch in several days and larval development takes place in water, wet marshy soil, decaying vegetation, or animal feces.

- Pupae follow the fourth larval molt, and adults emerge after several days.

c. Disease Transmission. *Culicoides* spp. transmits filariasis and several viral and protozoan diseases to wild and domestic animals, but are of primary importance to humans because of their vicious biting habits. These tiny, almost invisible flies are difficult to see and often occur in large numbers.

d. Nuisance. Their bites usually cause a raised area on the skin which may itch for several days.

3-9. TSETSE FLY (*GLOSSINA* SPP.)



Tsetse flies are generally confined to the area of tropical Africa south of the Tropic of Cancer.

a. Identification. Adults are medium sized stout appearing flies with a brownish color.

- They are somewhat more constricted between the thorax and the abdomen than most other flies and have wings that fold in a scissors-like fashion and extend well beyond the abdomen.

- The bayonet-like proboscis extends outward in front of the head when the fly is in a resting position. Both males and females are avid blood feeders and can fly at speeds over 20 miles per hour.

b. Life Cycle. Unlike most flies, the female tsetse fly gives birth to a full-grown larva, one at a time every 10 to 12 days over her lifetime.

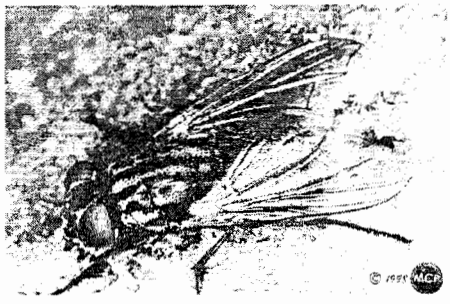
- The larva pupates almost immediately after it emerges.

- The female must take a new blood meal before a new larvae will develop.

c. Disease Transmission. The tsetse fly is the vector of African trypanosomiasis or African sleeping sickness, which may be caused by either of two *Trypanosoma* spp. Six different *Glossina* species are considered primary vectors of the disease.

Section III. NONBITING FLIES

3-10. HOUSE FLIES (*MUSCA DOMESTICA*)



The house fly is one of the most widely distributed insects, occurring throughout the U.S. and the world. It is usually the predominant species in homes and restaurants. Because of its close association with people, its abundance, and its ability to transmit disease, it is considered a greater threat to human welfare than any other species of nonbiting fly.

a. Identification. The house fly is grayish. Its thorax is marked with four equally broad, indistinct, dark, longitudinal stripes. House fly mouthparts are sponge-like and can only take up food in liquid form. When the fly is not using them, they may be partly withdrawn into the head.

b. Development. Egg and larval stages develop in animal and vegetable refuse. Favorite breeding sites include garbage, animal manure, spilled animal feed, and soil contaminated with organic matter such as washings of any of those items.

c. Life Cycle. House flies are very prolific; each females lays several masses of many eggs.

- Under favorable conditions, these eggs hatch in 24 hours or less. Larvae (maggots), are creamy white and about 1/2 inch long when mature.
- Maggots move about in the larval development site to secure optimum temperature and moisture conditions.
- The larval stage lasts 3 to 24 days, the usual time in warm weather being 4 to 7 days.
- To pupate, larvae move to dry areas of the development site or move out of it onto the soil or sheltered places under debris.
- The pupal stage usually lasts four to five days, but under very warm conditions only three days may be needed; in cold weather, flies may remain in the pupal case for several weeks.
- When the pupal stage is complete, the adult pushes open the end of the pupal case, works its way onto the surface ground, and after drying and harding, flies away to feed.
- Mating may take place soon after emergence.

d. Disease Transmission. House flies transmit many human enteric diseases, such as dysentery, cholera and typhoid fever. Sometimes these organisms are carried on the fly's tarsi or body hairs, and frequently they're regurgitated onto food when the fly attempts to liquefy it for ingestion.

-- ATTENTION --

Because the house fly has a wide flight range and varied food preferences, and because the female is naturally attracted to filth where she can lay her eggs, the presence of flies in dining facilities or homes is both dangerous and unsightly.

3-11. BLOW FLIES (FAMILY CALLIPHORIDAE)

Blow flies may be identified by their relatively large size and shiny or metallic blue, green, bronze, or black abdomens.

- Some species breed in living animals and others breed in dead animal tissue.

- Various species of flies breed in meat scraps and decaying vegetable matter.
- Adults are strong fliers and are attracted to oviposition sites from long distances.
- The blow fly life cycle is similar to that of the house fly.
- While they have the same potential to transmit disease organisms as do house flies, they have fewer opportunities because they're less likely to enter buildings.
- Immature stages have often been found in human and animal wounds, and many species of blow flies cause myiasis (invasion of human tissue).

EXERCISES, LESSON 3

REQUIREMENT. Answer the following questions by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. List three diseases that flies can transmit to humans.

   a. _____

   b. _____

   c. _____

2. The one thing stable flies, horseflies, black flies, and sand flies have in common is _____

3. How can the stable fly be distinguished from the house fly? _____
   _____
   _____
   _____

4. Several species of black flies are the host for the disease _____ .

5. How can a sand fly be recognized?
   _____
   _____

6. Complete these sentences about the Tsetse fly.

a. These flies are generally found in _____.

b. The Tsetse fly can fly at speeds over _____.

7. The Tsetse fly is the vector of _____.

8. Although biting midges do transmit diseases to wild and domestic animals, midges are of primary importance to humans because of _____

_____

9. List three enteric diseases the house fly can transmit to humans.

a. _____

b. _____

c. _____

10. List three reasons the house fly is considered a greater threat to human welfare than any other species of nonbiting fly.

a. _____

b. _____

c. _____

LESSON ASSIGNMENT

LESSON 4	Filth Fly Control.
LESSON ASSIGNMENT	Paragraphs 4-1 through 4-11.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to employ integrated pest management principles against flies IAW AFPMB *Military Management Handbook*, and Pest Control Technology, *Field Guide for the Management of Structure Infesting Flies*.
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the references listed above, you should be able to: 4-1. Identify the purpose for conducting filth fly surveillance. 4-2. Identify the sampling methods used for filth fly surveillance. 4-3. Identify the integrated pest management practices utilized in an effective filth fly control program.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 4

FILTH FLY CONTROL

Section I. SURVEILLANCE

4-1. INTRODUCTION

The management of flies in and around structures can sometimes be difficult and almost always proves interesting. No two situations are exactly alike but each control effort will involve many common steps. Before beginning any management program, you must correctly identify the flies that are causing the problem. Failure to correctly identify the fly or flies involved often leads to the failure in controlling or eliminating the infestation.

4-2. SURVEILLANCE

We conduct fly surveillance and identify sites suitable for filth fly development so that we can take corrective measures.

- Sanitation is the cornerstone of a sound filth fly control program.
- We conduct surveys to determine the effectiveness of sanitary practices and to determine the need for pesticide applications.

- Surveillance can verify that exclusion measures in food handling facilities adequately prevent fly access and subsequent contamination of food.

4-3. DEVELOPING A FILTH FLY SURVEILLANCE PROGRAM

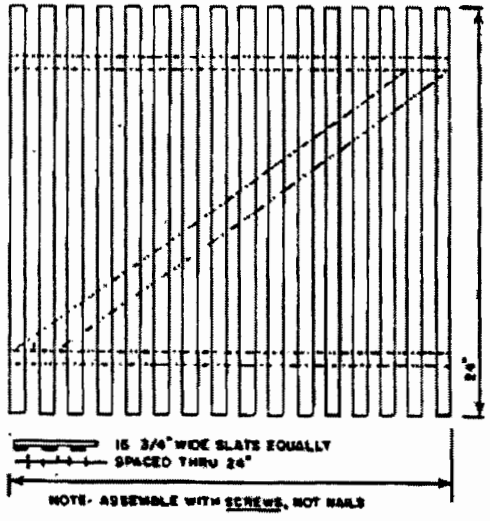
Develop a list of all potential filth fly infestation sites.

- A list of facilities that receive sanitation inspections is a good place to begin.
- Include landfills, stables, kennels, and refuse containers in housing, barracks, hospital, and recreational areas.
- Conduct a preliminary survey at all potential filth fly infestation sites listed to determine the existing infestations.
- Meet with managers of food handling facilities, kennels, stables, housing and barracks areas, etc. to discuss measures for a successful fly control program.

4-4. SAMPLING METHODS

Conduct weekly adult filth fly sampling at a standard time and at the same locations throughout the fly breeding season. Sampling methods used in securing fly population estimates must be the same from one survey to the next.

a. Fly (Scudder) Grill. Fly grill technique enables a person to make a visual estimate of the number of flies in an area.



- A trained operator places the grill over an attractant, and counts the number of flies landing on the grill or a portion of it in a given period of time, usually 1 minute.
- With practice it is possible to keep counts on several species at once.
- Counts for the same area will vary for different operators.
- Records of grill counts should be maintained. They are useful for demonstrating the effectiveness of control measures and for determining when re-treatment is required.
- A standard index may be obtained for measures and for strategic locations by averaging two or more readings per week.
- When this index is plotted in graph form by weeks, the relative fly population in each area may be determined at a glance.

b. Fly Trap. The fly trap is in essence a screen cage with a funnel type entrance which may be placed over a bait selected to attract several species of domestic flies.

- Flies leaving the bait fly upward through the funnel opening and are trapped alive.
- A varied bait containing garbage, fruit, meat or fish, and some animal feces will attract several species of flies in addition to house flies. Commercial baits are available.
- Fly trap counts may furnish a quantitative index of fly populations but remember that they should be placed in the same location each day and be baited with the same bait each day it used for this purpose.

4-5. RECORDING SURVEILLANCE DATA

Keep a permanent record of all filth fly surveillance data. For example, the U.S. Army uses DA Form 8015-R (Filth Fly Survey) to provide a record of the number of filth flies counted or trapped, the species observed, and sanitation and

exclusion conditions in each facility surveyed. A composite index for a particular area or installation is calculated by averaging together several collection sites. The composite indices should be plotted in graph form. A treatment threshold may be established with some experience.

Section II. INTEGRATED PEST MANAGEMENT

4-6. CULTURAL

a. Sanitation. Good sanitation practices are a key step in successful long-term management of most filth fly infestations. If poor cleaning practices allow the accumulation of moist organic debris, these flies can breed in large numbers throughout a facility. Regular cleaning with special attention to problem areas can be quite effective in preventing re-infestations.

b. Source Reduction. Source reduction also plays a major role in managing filth flies such as the house fly and blow flies. Poor sanitation in outdoor areas as well as poor trash handling practices can attract these flies in large numbers to the vicinity of a building. The more flies present near the building, the greater the likelihood of flies entering the building.

4-7. MECHANICAL

a. Screening. Whether or not good sanitation practices are being followed outside, filth flies can still enter building if doors are propped open, door and window screens are not in place, or cracks are present in the exterior of the building.

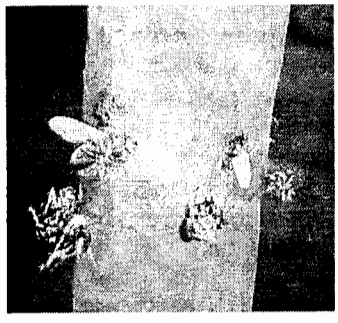
- Keeping flies out by sealing them out is the most effective measure to control flies inside buildings.
- Doors and windows must be kept closed at all times unless proper screens (minimum size is 12 mesh) are in place.
- The screens installed in doors, windows, and over vents may need to be closely examined to ensure that they are intact and that the mesh size is sufficiently small for the species present.

b. Air Curtains. These devices are installed above doorways and are activated when the door is opened.

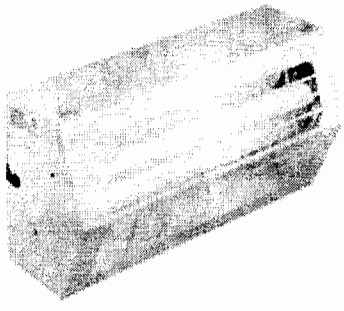
- In order for an air door to effectively exclude insects, it must project a continuous current of air at an angle away from the entryway with sufficient force (minimum velocity 1600 ft/min) to prevent fly entry.
- Air curtains are more effective when installed between interior rooms than in outside doorways.

c. Traps. Many traps have been developed for managing flies over the years.

- The original fly trap was fly paper which was placed or hung in areas where flies frequent.



- Sticky traps utilizing baits and/or attractive colors and markings are hung in windows, and other areas with fly activity.
- Light traps can be very effective management tools provided they are properly placed in a building and are kept a sufficient distance from food preparation areas.



4-8. BIOLOGICAL

a. Parasitic Wasps. The use of parasitic wasps has been used as a control method in some situations.

b. Sterilization. The release of sterilized male flies has been used to control the reproduction of Primary screwworms and Mediterranean fruit flies. This technique is only useful in limited situations.

4-9. REGULATORY CONTROL

The enforcement of sanitation standards will greatly reduce many fly problems. This control method closely parallels cultural control in that it enforces the use of good sanitation practices to control fly problems. This may be manifested in several ways to include: proper disposal of waste, landfill operations, and contracts for periodic garbage collection.

4-10. CHEMICAL CONTROLS

The application of insecticides is generally the last step in any fly management program. In most situations, the larval development sites must be found and removed, sanitation must be improved and steps to exclude flies taken before considering any insecticide applications.

a. Baits. Poison baits are used effectively for control of houseflies in many situations. Baits reduce fly populations quickly but require frequent application or the use of regularly serviced bait stations.

- Granular dry baits prepared with sugar or cornmeal are recommended.
- Sugar baits are easier to prepare.
- Baits should not be used in homes but are acceptable for use in dairies and food processing plants, including commissaries, exchanges, and similar facilities.
- Bait stations may be employed effectively where scattering baits is not desirable.
- Where fly populations are extremely heavy, fixed bait stations may become so clogged with dead flies that contact with the bait is impossible and frequent servicing may be required.

b. Residual Sprays. Applying insecticides to exterior surfaces on which flies rest may provide effective control. Apply insecticides to resting places frequented by flies in food service facilities and other living or working spaces. An insecticide may be applied to screen with a paintbrush.

c. Space Sprays. Space sprays can be used effectively inside buildings for the prompt elimination of flies. However, they have no lasting effect, and require frequent re-treatment. Space sprays are even less satisfactory outdoors and must be repeated at least daily where there is continuous production and infiltration of flies.

4-11. INTEGRATED APPROACH

A good fly management program will usually use two or more of the above control methods depending on the situation. Fly control is a true example of integrated pest management where insecticides are used sparingly in the overall control program. Finding the source of the infestation and correcting conditions contributing to it are the keys to successful fly management.

EXERCISES, LESSON 4

REQUIREMENT. Answer the following exercises by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. What is the primary purpose of filth fly surveillance? _____

_____

2. To develop a filth fly surveillance program, begin by _____

_____

3. In developing a filth fly surveillance program, you should meet with managers of food handling facilities, kennels, stables, housing and barracks areas to discuss _____

_____

_____

4. To use the fly grill sampling technique, a trained operator _____

_____

_____

_____

5. A fly trap is a technique for sampling adult filth flies. The fly trap can be described as

_____

_____

_____

_____

6. To use the fly trap count for a quantitative index of fly populations, you should remember to do two things:

a. _____

_____

b. _____

_____

7. Where are air curtains most effectively installed? _____

_____

_____

8. List two disadvantages of using space sprays to eliminate filth flies indoors.

a. _____

b. _____

9. Before considering chemical controls of filth flies, you should:

a. _____

_____

b. _____

_____

c. _____

_____

10. List the keys to successful fly management.

a. _____

b. _____

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LESSON ASSIGNMENT

LESSON 5	Biology and Identification of Cockroaches.
LESSON ASSIGNMENT	Paragraphs 5-1 through 5-15.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to identify cockroach species and their natural history IAW AFPMB *Military Pest Management Handbook*.
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the reference listed above, you should be able to:

5-1. Identify the primary importance of cockroaches.

5-2. Identify the general characteristics and life cycle of cockroaches.

5-3. Identify the food preferences of the following cockroaches:

- American cockroach
- German cockroach
- Brown-banded cockroach
- Oriental cockroach
- Smokey brown cockroach

5-4. Identify the habitat preferences for the following cockroaches:

- American cockroach
- German cockroach
- Brown-banded cockroach
- Oriental cockroach
- Smokey brown cockroach
- Brown cockroach
- Asian cockroach
- Australian cockroach
- Wood cockroach
- Turkistan cockroach

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 5

BIOLOGY AND IDENTIFICATION OF COCKROACHES

Section I. GENERAL INFORMATION

5-1. INTRODUCTION

Cockroaches are among the world's most common and cosmopolitan insects. They've been on earth about 400 million years and there may be as many as 7500 species worldwide. In the United States, there are approximately 55 species.

- These insects prefer a moist warm habitat; most are tropical in origin.
- Some tropical cockroaches feed only on vegetation; however, those that live in structures are usually omnivorous scavengers.
- Cockroaches are highly adaptive and able to exploit changing circumstances.

5-2. IMPORTANCE

Cockroaches are important primarily because of the cost of managing them in all types of structures, including ships and aircraft. Only the ants have recently surpassed their importance in structures (largely due to more effective cockroach control through the use of baits). In recent years as much as 50% of the services engineering pest management budget has been devoted to cockroach management on military installations.

a. Food Source. Cockroaches are omnivorous but are especially fond of starch materials such as cereals, sweetened or sugary substances, and meat products. They may also feed on cheese, beer, hair, wallpaper and dead animals. They eat books, especially those soiled with perspiration, and may feed on the binding of books in order to get to the paste beneath the binding. Some plant-feeding species are also important pests in greenhouses.

b. Possible Disease Transmission. Although cockroaches have never been incriminated as disease vectors in epidemics, their close association with people and food supplies necessitates effective cockroach management.

- Cockroach behavior and body structure makes them well adapted for mechanically transmitting diseases, and laboratory experiments have shown that such transmission is possible.
- They can carry disease organisms and deposit them along with excreta on food, but it is difficult to substantiate natural disease transmission.
- Cockroaches should be managed even if they aren't important disease vectors because they have unsanitary behavior and contaminate food with excreta.

c. Odor. There's often an unpleasant odor associated with cockroach excreta. Dishes and liquid foods may retain this odor for long periods of time. Dishes cockroaches walk over may emit an unpleasant odor when filled with warm food.

d. Allergic Reactions. Cockroaches cause allergic reactions in some people, producing asthma-like disease symptoms.

Section II. GENERAL CHARACTERISTICS AND LIFE CYCLE

5-3. METAMORPHOSIS

Cockroaches undergo gradual metamorphosis, with egg, nymph and adult stages. Females produce purse-shaped egg cases called oothecae. Each ootheca contains two rows of eggs. All fertile eggs in the ootheca hatch simultaneously because the combined efforts of all nymphs are needed to escape from the capsule.

5-4. NYMPHS

Nymphs resemble adults but are smaller and lack functional wings. As the nymphs grow,

they molt several times; after the last molt the wings are fully formed and the cockroaches are sexually mature.

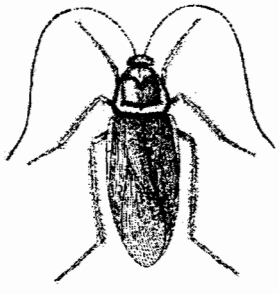
5-5. ADULTS

Adult cockroaches may have long, functional wings or they may have short or rudimentary wings, depending on the species. In some species males are winged but females have only rudimentary wings. Most cockroaches are nocturnal and secretive in habit, but some species are active during the daytime, especially if large populations are present and food is scarce.

Section III. BIONOMICS OF COCKROACHES

5-6. AMERICAN COCKROACH (*PERIPLANETA AMERICANA*)

a. Identification.



- The American cockroach is the largest of the common species, growing to a length of 1-1/2 inches or more.
- Adults are dark reddish brown to dark brown in color, with light markings on the margins of the thorax.
- Both sexes are winged. The male's wings extend beyond the tip of the abdomen and the female's are about the same length as the abdomen.

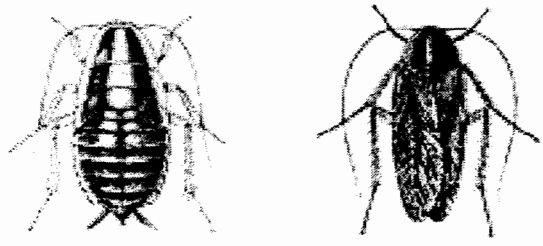
b. Life Cycle.

- Females drop their oothecae within a day after they are formed. They may simply be dropped in a suitable location or glued to a surface with oral secretions.
- Females form 15 to 90 oothecae at a rate of about one per week. Each ootheca contains 14 to 16 eggs. At room temperature, nymphs hatch out in 45 to 55 days. As they hatch, the nymphs molt, leaving thin cast skins in the egg case.
- Under ideal conditions, nymphs can reach maturity in 5 months. However, under adverse conditions, 12-24 months may be required for sexually mature adults to develop.

b. Habitat. American cockroaches prefer a warm, moist habitat.

- They're common in food-handling establishments and industrial plants, hiding in drains and dishwashing areas.
- Outdoors, they live under tree bark, in sewers, or in underground utility chases.
- This species may travel directly from the sewer to your home carrying organisms on its body and legs that could contaminate your food and kitchen surfaces.
- In southern states, it's also possible to find them living in palm trees.

5-7. GERMAN COCKROACH (*BLATTELLA GERMANICA*)



Nymph Adult

a. Identification.

- The German cockroach is the most common cockroach on most military installations as well as in households. Adults are about 5/8-inch long.
- Adults are light brown with two dark longitudinal stripes on the thorax.

- Both sexes have fully developed wings.

b. Life Cycle

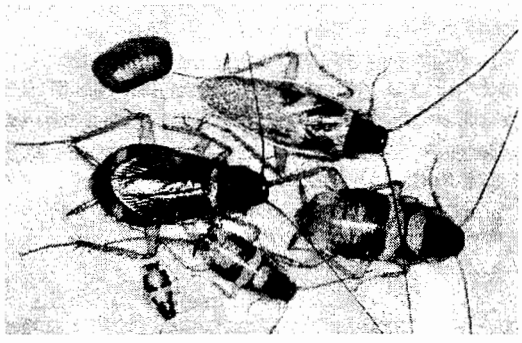
- German cockroaches mature in about 5 months. However, under adverse conditions, it may take 12-24 months. They generally mature faster than other species.
- The number of eggs in the ootheca varies from 18 to 50 with a mean of 32, and the female carries the ootheca until shortly before hatching.
- Female German cockroaches may occasionally help the nymphs emerge from the egg capsule.
- The average life cycle takes 60 days at room temperature.

b. Behavior.

- German cockroaches are very gregarious. Gravid female cockroaches spend more time in harborage than other life stages. This makes it extremely difficult to manage this species unless extreme care is taken in thorough treatments.
- In populations that have developed pesticide resistance, individuals may scatter widely throughout a building after chemical treatment. This species develops resistance to pesticides rapidly.
- Although German cockroaches are normally most active at night in dark areas, people may see them out of their normal hiding places wherever they aren't disturbed.
- German cockroaches are very active, but cannot fly. They travel readily from one location to another and pass through very small openings. They're often carried from place to place in items such as bagged potatoes and onions, bottle cases and cartons and food packages.

c. Habitat. German cockroach habitats are usually warm, dark, and have small cracks and crevices or other small openings into dark confined areas. Such places will generally be rather moist or located near water sources and food supplies.

5-8. BROWN-BANDED COCKROACH (*SUPELLA LONGIPALPA*)



a. Identification

- This is one of the smaller cockroach species. It measures approximately one half inch long.
- It is light brown in color and is easily distinguished from the German cockroach by two light transverse bands across the base of the wings and abdomen.
- Females of this species have a broader abdomen than males.

b. Life Cycle.

- The female carries the capsule for 24 to 36 hours and then attaches it to some object. Egg capsules are yellow to reddish brown in color and measure about 3/16 inch long.
- Each female produces about 14 oothecae in her lifetime, each containing about 18 eggs.
- Eggs hatch in 50 to 75 days, depending on temperature.

d. Habitat and Range.

- This cockroach originally occurred only in the southern states but is now found as far north as Canada, even though it's most prominent in the southern U.S.

- Brown-banded cockroaches are commonly found in clusters; they hide in cupboards, pantries or other rooms in houses.
- They prefer high, dry locations such as shelves in closets, behind pictures picture moldings, etc. These roaches may also infest electrical appliances such as televisions and radios.
- Brown-banded cockroaches are commonly associated with other species.
- They may deposit egg capsules in and around the kitchen sink, desks, tables and other furniture. This may account for its spread northward.
- This species is most active at temperatures above 80°F; activity and development slow down considerably at temperatures below 75°F.

5-9. ORIENTAL COCKROACH (*BLATTA ORIENTALIS*)

a. Identification.

- This species is dark brown to black in color.
- Females are 1 to 1½ inches long and have only rudimentary wings reduced to small lobes.
- Males are a little shorter than females and have fully developed wings that don't extend to the end of the abdomen.

b. Life Cycle.

- A female will carry her ootheca for about 30 hours before she drops or attaches it to a protective surface near a food supply.
- The average female will produce 8 capsules, each having 16 eggs that hatch in about 44 days.

c. Behavior.

- This species is less wary and more sluggish than other common cockroaches.
- It may enter the home in food packages and laundry, or merely come in under the door or through air ducts or ventilators.
- This is a notably gregarious species, commonly being found in large colonies.

d. Habitats and Range

- The oriental cockroach is found throughout the United States.
- It is common in sewers, utility chases, in dark, damp basements, and is known to climb water pipes to upper floors in apartment houses.

5-10. SMOKEY BROWN COCKROACH (*PERIPLANETA FULIGINOSA*)

a. Identification.

- The smoky brown cockroach is closely related to the American cockroach but is smaller, being slightly more than one inch long, and has a uniform mahogany color.
- Both sexes have wings longer than their bodies.

b. Life Cycle

- It normally feeds on plants and is a common pest in greenhouses, homes and other buildings.
- Egg capsules of the smoky brown cockroach normally contain 24 eggs.

The female carries the capsule for 24 to 36 hours and then deposits it in a secluded location.

- Each female produces about 17 egg capsules in her adult life.

c. Range.

- This cockroach is common in the southern U.S., where it's often the most common large cockroach pest. It has been found in many areas as far north as Indiana.
- It frequently invades houses from flower beds and other areas near the house that are mulched.

5-11. BROWN COCKROACH (*PERIPLANETA BRUNNEA*)

a. Identification.

- This species closely resembles the American cockroach but is generally broader in relation to length and has slightly less distinctive markings on the thorax.
- The last segment of each cercus is short and broad.
- The basal and distal segments of the first instar nymph's antennae are white.

b. Life Cycle.

- Females produce an average of 17 egg capsules, each one holding about 24 eggs.
- At normal temperatures, incubation takes about 50 days.

c. Behavior. Young nymphs have the distinct characteristic of running about with their abdomens curled up.

d. Habitat and Range

- The brown cockroach is found in the southern U.S. from Florida to Texas north to Pennsylvania and Ohio.
- Brown cockroaches prefer to feed on plant materials and normally are found outdoors under the bark of trees, but they also may occur indoors.

5-12. ASIAN COCKROACH (*BLATTELLA ASAHINAI*)

a. Identification.

- It is very similar in appearance to the German cockroach except that its wings are longer and narrower and extend beyond the tip of the abdomen.

b. Life Cycle.

- Development time is six to seven weeks; slightly shorter than the German cockroach development time.
- Each ootheca contains about 40 eggs.

c. Behavior.

- Asian cockroaches readily move indoors and can establish active populations.
- They fly readily and are very active at sunset when adults are attracted to bright surfaces such as white walls and illuminated buildings.
- If disturbed, adults often climb onto blades of grass and fly short distances (usually two meters or less) then return deep into the lawn.

d. Habitat and Range.

- This is a very recent introduced species of cockroach on the North American continent.
- It was apparently introduced into central Florida and based on its range in Asia, scientists are concerned that it may spread throughout the southern U.S. and as far north as Maryland on the East Coast and Washington on the West Coast.

- During the day all stages can be found beneath the thatch, under leaf litter or on soil in heavy grass. This species prefers shaded areas. German cockroaches, in contrast, only occasionally go outdoors.

5-13. AUSTRALIAN COCKROACH (*PERIPLANETA AUSTRALASIAE*)

a. Identification.

- The Australian cockroach is similar to the American cockroach but is slightly smaller, measuring about one inch long.
- This cockroach has yellow margins on the thorax and a dark spot on the pronotum.
- Nymphs are brightly marked with distinct splotches of yellow on the dorsal side of the thorax and abdomen.

b. Life Cycle.

- Adult females drop their egg capsules shortly after they're formed and eggs hatch about 30 days later.
- There are about 24 eggs per capsule, but only 60 percent of this number usually hatch.
- A female will produce a new egg capsule about every ten days.

c. Habitat.

- This cosmopolitan species is found in many greenhouses and is apparently a vegetarian.
- Nevertheless, it's also a pest in homes where it may eat holes in clothing and feed on starchy materials.

5-14. WOOD COCKROACH (*PARCOBLATTA* SPP.)

There are several different species of cockroaches -- including the wood cockroach -- that normally live outdoors where they present no real problem.

- They may become indoor pests if they're accidentally introduced indoors via such items as fireplace logs or outdoor furniture not cleaned before winter storage.
- Unlike most cockroaches, these species are attracted to light.
- People typically call these insects "wood roaches."

5-15. TURKESTAN COCKROACH (*BLATTA LATERALIS*)

This cockroach is probably the newest species to enter North America. It was first found in the U.S. at a military supply center on the West Coast. Its economic importance, if any, isn't yet established

Cockroach	Adult Characteristic	Life Cycle Feature	Food Preference and Habitat
German Cockroach	5/8" or shorter Pronotum with 2 black bars	Many eggs and short life cycle Carry egg capsule	Fermenting foods Kitchens and other areas close to food and water
Brown-banded Cockroach	5/8" or shorter Wings banded with yellow stripes	Glue eggs to surface Long life cycle	Starch materials Attics and electrical appliances
Oriental Cockroach	Longer than 5/8" Wings absent or short Dark brown to black	Glue eggs to surface or deposit in trash Long life cycle	Decaying organic matter Damp areas, sewers and trash
American Cockroaches	Longer than 5/8" Pronotum with pale areas Reddish to medium brown	Glue eggs to surface or deposits Long life cycle	Decaying organic matter and sweets General habits, common in sewers
Smoky brown Cockroach	Similar in size and color to American Soiled dark pronotum	Glue eggs to surface or deposit Long life cycle	Plant materials Found in crawl spaces, trees, sewers, Common outdoors

Summary of Key Features in the Life Cycle and Habits of Common Cockroaches.

EXERCISES, LESSON 5

REQUIREMENT. Answer the following questions by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. What is the primary importance of cockroaches besides the fact that they deposit their excreta indiscriminately? _____

_____
_____

2. What do cockroaches eat?

_____
_____

3. a. What is an ootheca? _____

_____
_____

b. What type of metamorphosis do cockroaches have? _____

_____

_____

4. List three outdoor places American cockroaches live.

a. _____
b. _____

c. _____

5. Why is it difficult to eradicate adult female oothecae-carrying German cockroaches?

_____

6. The _____ cockroach eats starch materials and lives in attics and electrical appliances.

7. The _____ cockroach, apparently introduced to this continent in central Florida, lives beneath the thatch, under leaf litter, or on soil in heavy grass.

8. How can young nymphs of brown cockroaches be easily identified?

_____
_____

9. How does the female Oriental cockroach differ from the male? _____

_____
_____

10. _____ cockroaches may become indoor pests if they are accidentally introduced via such items as firewood or outdoor furniture brought inside for storage.

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LESSON ASSIGNMENT	
LESSON 6	Cockroach Control.
LESSON ASSIGNMENT	Paragraphs 6-1 through 6-13.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to employ integrated pest management principles to cockroaches IAW TB MED 561, *Occupational and Environmental and Health Pest Surveillance*, and AFPMB *Military Pest Management Handbook*.
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the reference listed above, you should be able to: 6-1. Identify the three components of a cockroach surveillance program. 6-2. Describe the methods for trapping cockroaches or assessing their presence. 6-3. Identify measures to prevent and correct cockroach infestations.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 6

COCKROACH CONTROL

Section I. COCKROACH SURVEILLANCE

6-1. INTRODUCTION

Cockroaches are often the most common arthropod pest encountered by PVNTMED personnel. Although current cockroach management techniques are highly successful, it still requires significant resources and knowledge to conduct effective control measures. Historically, at many U.S. military installations, it has been a common practice to apply pesticides for cockroach control on a routine, scheduled and preventive basis. DoD policy prohibits the use of preventive or scheduled periodic pesticide application unless approved by the pest management consultant and based upon surveillance data or past pest problems.

6-2. ESTABLISH A PROGRAM

Because cockroaches are primarily nocturnal, they may be easily overlooked during daytime inspections. Surveillance techniques must compensate for this problem.

a. Components of Cockroach Surveillance. A comprehensive cockroach surveillance program must be established at each installation. This is normally the responsibility of the Preventive Medicine personnel at the

installation hospital or clinics and should be integrated into their routine sanitary inspections.

- Acquire a list of facilities that receive sanitation inspections.
- Since family housing does not receive routine cockroach surveillance, it should not be included on this list.
- Select the methods and frequency for sampling cockroach populations on the installation.
- Initiate cockroach surveillance that includes collection of cockroaches and evaluation of facilities for conditions that are conducive to cockroach infestations.
- Good floor plans are essential to conduct cockroach surveillance.

b. Data Collection. The number of cockroaches collected can vary greatly from one location to another, therefore, to obtain data that is comparable over a period of time, the repeated collections must be from the same location.

6-3. COLLECTION METHODS

a. Sticky Traps. Standard cockroach sticky traps (NSN 3740-01-096-1632) have been used by DOD for several years for detecting and monitoring cockroach populations. While these traps cannot be used alone to effectively reduce cockroach populations, they can generate data used to:

- Identify the pest species present.
- Evaluate the impact of treatment regimens.
- Locate approximate areas where insecticide treatments should be used.
- Locate where infestations are occurring in a facility.

b. Live Traps. Live traps provide quantitative data for cockroach surveillance. Live traps are not as convenient to use as sticky traps for routine cockroach surveillance because of the problem of disposal of live cockroaches. Live specimens may be required for resistance testing or when sticky traps are not available.

c. Nighttime Surveys. A nighttime cockroach survey is a thorough examination of a facility for the presence of cockroaches and conditions conducive to cockroach infestation. Cockroaches are most active at night. As a result, they are not usually seen during the day unless the infestation is very heavy. At night, the foci of the infestation can be observed. In addition, sanitation, harborage areas, and food storage conditions conducive to cockroach infestation are readily apparent. Nighttime surveys are difficult to coordinate and arrange and very time consuming. They should be used as a supplement to routine cockroach trapping to evaluate special control problems.

6-4. RECORDING SURVEILLANCE DATA

Keep a permanent record of all cockroach surveillance data. Maintain a file of cockroach surveillance data for each facility on the installation. For example, DA Form 8014-R (Cockroach Survey) provides a record of the number cockroaches collected in each trap and the sanitation and harborage conditions in each facility. Calculate and record, for each facility, the average number of cockroaches per trap per night. A graph showing changes in the population level and dates of pesticide application allows you to visualize population trends and treatment efficacy.

Section II. COCKROACH MANAGEMENT

6-5. INTRODUCTION

Cockroach management involves both preventive and corrective measures. To be effective, control measures must be tailored to fit the habits of the species requiring management.

6-6. PREVENTIVE MEASURES

a. Sanitation. Proper storage procedures and cleanliness are essential requirements in a cockroach management program.

- All food materials must be properly stored so cockroaches have no access. Make sure garbage and other refuse is in containers with tight-fitting lids.

- Spilled foods and waste materials should be cleaned up and disposed of daily.
- Kitchen or galley equipment should be raised adequately above the floor to permit easy cleaning.
- All food preparation equipment and utensils should be thoroughly cleaned at each day's end.
- Empty drink bottles should be washed out and placed outside where they will not attract roaches indoors.
- Empty cardboard boxes should be removed immediately. German cockroaches in particular use corrugated cardboard as harborage and they also may eat the glue.

b. Entry Prevention. German and brown-banded cockroaches are the two species most difficult to manage and yet these species are the easiest to keep out of buildings.

- All stages of these pests may be carried into buildings in food containers such as potato bags or cardboard boxes.
- Egg capsules brought in on furniture are another important source of infestation.
- Careful inspection of newly delivered materials can prevent most entries.

c. Harborage Elimination. Cockroaches don't normally infest structures that lack suitable hiding places. Unfortunately, most buildings and ships have harborages adequate to support large colonies.

(1) Objectives. Two objectives are served by working to eliminate these harborages: (1) this will reduce the size of the cockroach population the structure can support and (2) it makes chemical control actions more effective.

(2) Location. Look for typical harborage in dead spaces in walls, holes for plumbing and electrical lines, electric switch and fuse boxes. In food storage and processing areas, it's possible to find additional sites for cockroach harborage under, in and behind food storage containers, food preparation equipment, food holding and serving equipment, and dishwashing equipment.

- On ships, torn insulation, double walls and bulkheads, inaccessible areas behind stainless steel panels, torn pipe lagging and other protected areas give harborage to cockroaches.

(3) Sealing. To eliminate many of these harborages, the best tools are not pesticides, but rather materials such as caulking compounds or cement.

6-7. CORRECTIVE MEASURES

Managing established cockroach infestations usually requires the use of chemical insecticides or growth inhibitors in addition to preventive measures.

- Pesticides applied as liquids or dusts to surfaces over which cockroaches travel are less effective because this method requires cockroaches to get to the pesticide instead of putting the pesticide where the insects live.
- Once an infestation is greatly reduced or eliminated, baits containing a pesticide or growth inhibitor may be very effective for keeping the population in check or controlling occasional "trespassers."

6-8. CORRECTIVE MEASURE: BAIT STATIONS

- In areas where sprays or dusts aren't practical, such as around some electric motors, bait stations are appropriate.
- Pest managers may also use baits as a preventive measure.
- Perhaps the most effective use of bait stations is to apply a growth inhibitor, either to depress an existing population or provide barriers to new populations.

6-9. CORRECTIVE MEASURE: BORIC ACID

- Boric acid crystals or paste are safe and effective components of contemporary cockroach management programs.
- Boric acid acts as a stomach poison. It is ingested when cockroaches groom. Boric acid also abrades the cuticle of cockroaches upon contact, causing dehydration and death.
- This multiple action may be the reason that no resistance has developed to boric acid after nearly a century of use.
- It can be used in pesticide free areas, and is very long-acting except when wet. It can be incorporated in the construction of walls, placed behind baseboards, or applied to cracks and crevices using a syringe or caulking gun.
- Boric acid is a key component in many baits.

6-10. CORRECTIVE MEASURE: AEROSOLS.

The largest use of aerosol bombs in cockroach control is as a survey tool. Pyrethrum or synthetic pyrethroid aerosols sprayed into cracks, crevices, and other harborage areas irritate cockroaches and flush them from their hiding places.

- Also, use aerosols to supplement residual treatments to provide a quick, complete kill or cleanout of all cockroaches.
- Don't expect to achieve total cockroach control with aerosols alone.
- Fine mist sprays and aerosols from dispensers and fog generators may give a rapid knockdown, but some cockroaches may avoid contact, and others may be insufficiently exposed.

6-11. RESIDUAL INSECTICIDES

Residual pesticides applied as liquids and dusts are commonly used to control cockroaches.

a. Pesticide Formulations. There are a variety of chemicals and formulations to control cockroaches. Pest managers can simplify equipment calibration by selecting pesticide formulations for which application methods and rates are basically the same.

- In some locations, cockroach populations have developed resistance to certain chemicals; if this occurs locally, switch pesticides to control the pest problem.
- Unsuccessful control operations are an indicator of the need to evaluate susceptibility to the residual in use and the thoroughness of the application.

b. Dusts. Pesticidal dusts have many applications.

- Use dusts in place of liquid formulations if liquids could cause fires or electrical short circuits. This includes such areas as fuse boxes, electrical outlets, stoves, ovens and heaters.
- Dusts can be very effective when applied in wall voids.
- Also use dusts to supplement liquid treatments whenever possible, provided they don't cause an unsightly appearance.
- Dusts are effective for fairly long-term cockroach control under buildings if they remain dry.

c. Liquids. Liquid formulations for cockroach control work best when applied to harborage areas and cracks and crevices.

- Liquid formulations are especially successful for German cockroach control.
- Crack and crevice treatments are required in some areas such as in kitchens and other food-handling areas to avoid leaving surface deposits which might come in contact with food.

- Make crack and crevice applications using emulsions, solutions, suspensions, dusts and baits, consistent with product labels.

- Where a surface application is appropriate, apply sprays to baseboards, surfaces behind and beneath cabinets, refrigerators, sinks and other surfaces used by cockroaches.

- Then follow the spray treatment with a dust application, especially behind baseboards, backs of bulletin boards, and behind and beneath furniture that cannot be thoroughly treated with the spray.

- The residual spray should surround the space-treated area and still be wet when cockroaches tread upon it to escape the irritating aerosol.

6-12. CORRECTIVE MEASURE: Multiple Strategies.

Multiple or simultaneous strategies are often useful in cockroach management.

- Baits may be used to supplement spray and dust applications.

- For severe infestations, it may be necessary to use ultra low dosage (ULD) applications using pyrethrin or pyrethroid formulations in conjunction with residual sprays for a thorough cleanout.

6-13. FREQUENCY OF TREATMENT

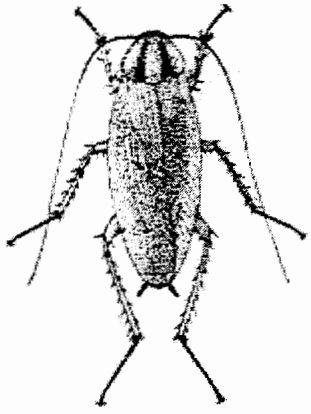
It often appears practical and convenient to set up a recurring schedule for providing cockroach control in some facilities. However, routine treatments should be used only as a last resort.

- It is more efficient for pest managers to focus on taking control actions only when they're called for by a thorough, properly conducted inspection survey.

- In turn, inspections should be scheduled based on the extent of the pest problem, the condition of the structure being treated, the thoroughness of previous treatments and insecticide(s) used.

6-14. CHEMICALS AND FORMULATIONS

For residual control indoors, many liquid pesticides labels call for an application rate of 1 gallon per 1,000 square feet. Chemical and growth inhibitor baits and ULD aerosol formulations of pyrethrins and pyrethroids are also available to use in combination with sprays. A well-balanced attack would be to use residuals as one component of a several-pronged approach that includes harborage control, bait stations, and boric acid application.



EXERCISES, LESSON 6

REQUIREMENT. Answer the following questions by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. The three components of a cockroach surveillance program are:

   a. _____

   b. _____

   c. _____

2. When should you use live traps for cockroach surveillance?_____
_____
_____

3. List two difficulties of nighttime surveys of cockroaches.

   a. _____

   b. _____

4. Preventive measures against cockroaches include removing empty cardboard boxes immediately because _____
_____
_____
_____

5. What are the two most difficult species of cockroaches to manage?

   a. _____

   b. _____

6. Two benefits of working to eliminate cockroach harborages are:

   a. _____
_____

   b. _____
_____

7. How do boric acid crystals or paste eliminate cockroaches? _____
_____
_____
_____
_____

8. It is appropriate to use liquid pesticide formulations in cracks and crevices in the kitchens and other food-handling areas because
_____
_____

9. In areas such as around some electric motors, the appropriate type of corrective measure is _____.

10. What is the largest use of aerosol pesticides? _____
_____

LESSON ASSIGNMENT

LESSON 7	Biology, Identification, and Management of Lice and Fleas.
LESSON ASSIGNMENT	Paragraphs 7-1 through 7-15.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to employ integrated pest management principles to control lice and fleas IAW AFPMB *Military Pest Management Handbook*.
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the reference listed above, you should be able to:

7-1. Identify the general characteristics of lice.

7-2. Identify the host and body area infested by the crab louse, head louse, and body louse.

7-3. Describe the apipropriate control measures for the three lice that infest humans.

7-4. Identify the general characteristics for fleas.

7-5. Describe the steps employed in a control program for fleas.

7-6. Identify the diseases transmitted by lice and fleas.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 7

BIOLOGY, IDENTIFICATION, AND MANAGEMENT OF LICE AND FLEAS

Section I. LICE (*ANOPLURA*)

7-1. INTRODUCTION

Lice have been intimately associated with humans for eons. They are most common in times of stress, such as war, famine, or other disasters when people can't or don't bathe or wash clothing regularly. For example, when people are crowded together in Enemy Prisoner of War (EPW) or refugee camps, lice are able to spread throughout the population quickly.

a. Effect of Lice. Anoplura (sucking lice) parasitize mammals, while Mallophaga (chewing lice) attack both mammals and birds.

- When feeding, lice inject an irritating saliva into the skin which causes considerable itching.

- Severe infestations may lead to scratching, secondary infections and scarred, pigmented skin conditions known as pediculosis.

b. Disease Transmission. In many parts of the world lice also transmit pathogens causing human disease.

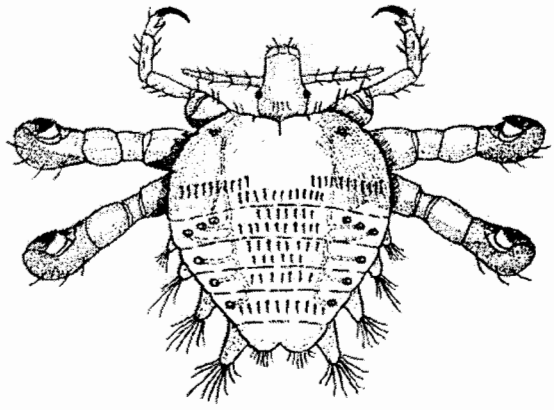
- The most important of these disease are epidemic typhus and relapsing fever, vectored by the body louse.
- All three human lice - body lice (*Pediculus humanus humanus*), head lice (*Pediculus humanus capitis*) and crab lice (*Phthirus pubis*) - cause dermatitis.

7-2. GENERAL CHARACTERISTICS

Sucking lice are dorsoventrally flattened, wingless insects.

- Their mouthparts have three stylets modified for piercing and sucking; the louse retracts them into the head when not using them.
- Their legs are short and stout, with a large claw on one or more pairs of legs for grasping and holding onto host clothing or hair.
- Louse eggs differ from most other insects eggs in that they're glued to hairs of the host or into seams of clothing and have a distinct cap or operculum.
- Immature stages are called nymphs, and they look much like adults.
- Females are usually larger than males and have the tip of the abdomen notched or bilobed.
- Sucking lice spend their entire life as ectoparasites on mammals.
- The body louse is a conspicuous exception since it rests on clothing except when it is feeding.
- All lice are host specific. Human lice infest humans and only humans.

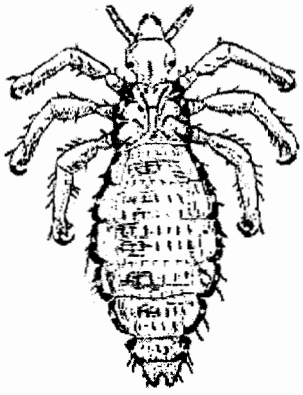
7-3. CRAB LICE (*PHTHIRUS PUBIS*)



Crab lice are small, whitish insects with a short abdomen and a large second and third pair of legs.

- This species is most commonly found on the hairs in the pubic region, but they may also be found on the hairy regions of the chest, armpits, and on facial hair.
- The crab louse's life cycle is similar to that of head and body lice.
  - -- Eggs are glued to hairs but they are smaller and have a more convex cap.
  - -- All stages of this louse are more sedentary than head or body lice.
- A crab louse tends to settle down at one spot, grasp on to body hairs, insert its mouthparts and feed intermittently for hours at a time.
- This species survives only a short time away from the host (24 hours at most).

7-4. HEAD AND BODY LICE



These two species are very similar and share common development and habitat characteristics.

a. Eggs. Eggs of these lice have a cap at one end to admit air for embryo development and to facilitate hatching. Head louse eggs are attached to hairs with a cementing material and are commonly called "nits." Body louse eggs are attached to fibers of clothing.

HEAD LOUSE EGG

b. Nymphs. After a nymph emerges from the egg, it undergoes three molts before it becomes a sexually mature adult. Nymphal stages take 8 to 9 days for lice that remain on the body, but may need 2 to 4 weeks when clothing is removed at night.

c. Adults. Adults differ little from the nymphs except in size and sexual maturity. The long body has three parts: head, fused thorax, and segmented abdomen. Males are usually smaller than females. Adult and nymphal head lice are found in the hair and on the scalp and are not know to infest eyebrows or eyelashes. Head lice tend to be most prevalent on the back of the neck and behind the ears. Body lice are most commonly found on the inner surface of clothing next to the skin. Adult females tend to congregate along seams to lay eggs.

7-5. SURVEY METHODS

As with any other type of survey, a louse survey involves finding insects or their eggs in a given host population.

- Head lice should be sought in the head hair while body lice will be found in the clothing, most commonly on the layer next to the skin.
- Crab lice are found in pubic and axillary regions and on facial hair.
- Given their limited and specialized habitat, routine surveys are not normally conducted specifically for human lice.
  - -- However, during medical treatment for lice, a qualified medical practitioner will examine the head and pubic areas for nits, nymphs, and adults.
  - -- If such problems are referred to a pest manager, it is important to inspect the infested individual's bedding and clothing articles and those of any people sharing quarters for the presence of lice.
  - -- Give special attention to seams of clothing, particularly trousers and to wool blankets for the presence of both lice and eggs.

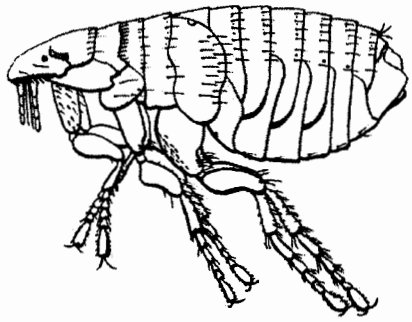
7-6. MANAGEMENT

Management includes delousing individuals and disinfecting clothing, equipment, facilities, ships, etc. All management operations for individual treatments for lice infestations are directed and conducted by **Medical** personnel.

7-7. MASS DELOUSING

Lindane powder has been recalled from the supply system and is no longer used in delousing. If delousing is required to halt the spread of typhus in EPW and DGRE camps, coordination needs to made with the Quartermaster Corp to locate laundry and bath units at the camps to provide the occupants with facilities to bath and to launder all clothing and bedding at regular intervals. New incoming personnel should be separated from the main camp until they have been deloused and had their clothing washed or new clothing issued.

Section II. FLEAS (ORDER SIPHONAPTERA)



7-8. INTRODUCTION

Fleas are of great importance as disease vectors in many parts of the world.

- From a medical standpoint, the most important fleas are those that are vectors of murine typhus and bubonic plague.
- However, fleas are also important because of their insidious attacks on humans and other animals, causing irritation, loss of blood, and extreme discomfort.
- In addition, fleas serve as intermediate hosts for some species of dog and rodent tapeworms that occasionally infest people, and they may act as intermediate hosts of filarial worms (heartworms) of dogs.

7-9. CHARACTERISTICS AND HABITS

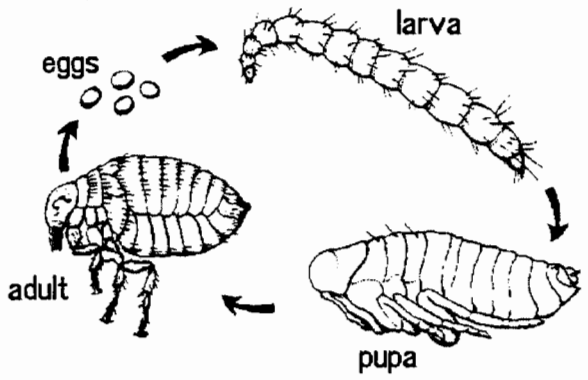
a. Identification. Fleas are small, wingless insects varying from 1 to 8.5 millimeters long, averaging 2-4 millimeters. The name of the flea order, Siphonaptera, refers to their method of feeding through a siphon or tube, and their wingless condition.

- The flea is a narrow insect compressed laterally with backwardly directed spines, which adapt it for moving between the hairs and feathers of mammals and birds.
- Their long, powerful legs are adapted for jumping.
- Mouthparts consist of three stylets used to penetrate the host's skin and suck blood.
- Both sexes feed on blood and the female requires a blood meal before she can produce viable eggs.

b. Choice of Hosts. Most flea species infest smaller animals such as rats, mice, rabbits, moles and bats; others are parasitic upon larger animals and birds.

- Most fleas are rather specific in their host preference, feeding only on one type of host.
- They are very sensitive to temperature and humidity extremes.
- This may explain their relative abundance on animals that live in burrows and sheltered nests, and light infestations on mammals and birds with no permanent nest, or those exposed to the elements.

c. Metamorphosis. Fleas undergo complete metamorphosis.



- The time it takes to complete the life cycle from egg to adult varies according to the species, temperature, humidity, and food.
- Under favorable conditions, some species can complete a generation in as little as 2 to 3 weeks.

(1) Eggs. Flea eggs are usually deposited among the feathers or hairs of the host or in the nest. They are often laid in carpets of living quarters if the primary host is a household pet. Eggs are smooth, spherical to oval, light colored, and large enough to be seen with the naked eye. A flea's full quota of eggs are laid, singly or in small groups over a considerable time period.

(2) Larvae. Larvae are small, 13 segmented, worm-like creatures with no legs and chewing mouthparts. The blind, active, whitish larvae are often found in homes in floor cracks and rugs, and in kennels, stables, animal burrows and nests. They feed on all types of organic debris, such as food crumbs, animal hair or dry flea feces containing partially digested blood. Completing the three larval stages may take a week or several months, depending on environmental conditions.

(3) Pupae. Pupae are usually enclosed in a cocoon of finely spun silk encrusted with granules of sand or various types of debris. The pupal stage lasts from a week to as long as a year.

(4) Adults. Adults are usually ready to feed about 24 hours after they emerge from the cocoon.

- Mating usually follows the initial blood meal.
- Some species apparently breed continuously; a generation can take a few weeks to a month or more in warm weather and longer in cooler weather.
- Other species have only one generation per year, such as many bird fleas in the genus *Ceratophyllus*.

7-10. DOG FLEA (*CTENOCEPHALIDES CANIS*).

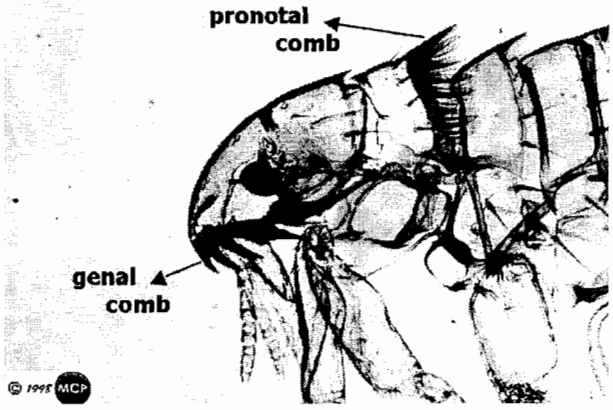
This flea is common throughout the U.S. and is considered a major household pest. Dogs, cats, and people are its primary hosts.

- This species prefers places where dust and organic matter accumulate; it's commonly found in quarters, under buildings and in yards.
- The dog flea is the intermediate host of the dog tapeworm, and people may become infected by accidentally infesting infected fleas from a pet during close contact with the animal.
- A person's typical reaction to a dog flea bite is development of small, hard, red, slightly raised, itching spots.

7-11. CAT FLEA (*CTENOCEPHALIDES FELIS*)

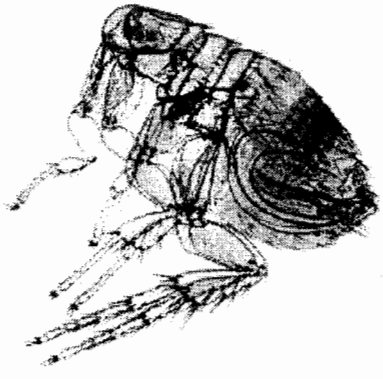
The cat flea's host, habitat, and biology are much like that of the dog flea. The two species also look very similar.

- To distinguish the cat flea from the dog flea, compare the length of the first two spines of the genal comb.



- In most cat fleas, the first two spines are about equal in length; on dog fleas, the first spine is shorter than the second.
- The cat flea is an intermediate host of the dog tapeworm and many researchers consider it to be the most prevalent species in the U.S.

7-12. Oriental Rat Flea (*Xenopsylla cheopis*).



This flea is the principal vector of bubonic plague and murine typhus.

- *Xenopsylla cheopis* were introduced throughout the world with the spread of Norway and roof rats, and is established throughout most of the U.S.
- It is found as far north as New Hampshire, Minnesota and Washington and is abundant during the summer and fall, becoming scarce in the winter months.
- Temperatures of 65° and 80°F with humidities of 70% or more are ideal for hatching eggs.

7-13. HUMAN FLEA (*PULEX IRRITANS*)

This flea's importance is based on its transmission of tapeworms and for causing dermatitis and allergy due to its bites.

- It is probably the most important flea to attack people on the Pacific coast.
- On farms, severe infestations are often traced to hog pens where these fleas have persisted for weeks or months after hogs where taken to market.

7-14. SURVEYS

Surveys are essential steps in managing flea-borne diseases.

a. The Focus of Surveys. Focus survey methods on sampling rodent populations and other small animals to learn the relative abundance of fleas in an area, or measuring flea numbers on rodents (or other small animals) to determine prevalent species.

b. Survey Method. The normal method is to determine ectoparasite numbers per animal and the percentage of animals infested by a particular flea species. To do this:

- First, trap rodents or other target hosts at numerous points in the survey area; use either snap or live traps.
- If snap traps are used, it's essential to observe them fairly frequently (at least within 8 hours of setting).
- Immediately place any catches in individual bags to keep fleas and other ectoparasites from escaping.
- Wear protective clothing to prevent personal attacks from escaping ectoparasites.
- If live traps are used, return them to a processing area, where the animals can be anesthetized and combed with a fine-toothed comb over a large white enameled pan to collect specimens.

- The pan should contain a small quantity of alcohol.

NOTE: Use surveys, made before and at intervals after dusting programs to measure the effectiveness and duration of management techniques.

7-15. MANAGEMENT

It is essential to manage fleas before controlling their rodent hosts; this will help minimize the spread of flea-borne diseases such as murine typhus and plague. If fleas are not controlled first, they'll leave dead rodents and are then likely to bite humans and transmit disease. Insecticidal dusts offer better control than residual sprays in these circumstances.

a. Burrow and Harborage Dusting. Apply an insecticide using a dust gun wherever rat burrows are found, such as in holes in floors and walls, and other enclosed spaces that may serve as rat harborages. It's especially important to treat spaces between double walls and floors, and under product shelves where there may be rat entries, since the potential for spreading disease form rodent to people is most severe in buildings. Apply dusts in a manner that leaves a light film covering the entire surface of each area treated.

b. Dust Patches. Dust patches consist of a layer of dust around currently used rat holes, entryways, or along rat runs. The thickness of each patch will depend on how often rats travel there; to make this determination, look for footprints and accumulations of rat droppings. Patches may vary from a thin film to a patch 1/4 to 3/8 inch thick. Make sure to thoroughly dust rat entries in an area having a 6 to 8 inches radius around each entry. Make runway patches about 6 inches wide and 18 inches long and place them on the narrowest part of the runway. If it is necessary to place patches on stairways, they should completely cover two adjacent stair trends.

c. Vacuuming. The use of vacuums can be very effective in reducing fleas indoors by removing eggs and larvae. Vacuums are especially beneficial when used in combination with pesticide treatments. After a vacuum is used for control, it is important to empty the bag to prevent the escape of fleas. Do not put insecticidal dusts in vacuum cleaner bags prior to vacuuming.

d. Insect Growth Regulators (IGRs). The use of IGRs for fleas can provide long term control. IGRs interrupt normal development of immature fleas. When combined with a quick know-down pesticide, IGRs can be particularly effective.

EXERCISES, LESSON 7

REQUIREMENT. The following exercises Are to be answered by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. Lice are most common in disasters when people _____

2. List two diseases lice transmit.

   a. _____

   b. _____

3. The louse which tends to settle down at one spot, grasp on to body hairs, insert its mouthparts, and feed intermittently for hours at a time is the _____ louse.

4. Where on the body are head lice predominantly found?

_____

5. Who conducts management operations for individual treatments for lice infestations?

_____

6. List two diseases that fleas vector.

   a. _____

   b. _____

7. When fleas attack humans in addition to disease, fleas cause:

   a. _____

   b. _____

   c. _____

8. a. The human flea can transmit _____.

   b. Bites of the human flea can cause _____ and _____.

9. In flea management, control fleas first and then manage their rodent hosts. Do this because

_____
_____
_____

10. How do you obtain a flea survey when you are using live traps for rodents?

_____

_____
_____
_____

LESSON ASSIGNMENT	
LESSON 8	Biology, Identification, and Management of Ticks and Mites.
LESSON ASSIGNMENT	Paragraphs 8-1 through 8-19.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to employ integrated pest management principles against ticks and mites IAW AFPMB *Military Pest Management Handbook*.
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the reference listed above, you should be able to: 8-1. Identify the life cycle of chigger mites, house dust mites, and scabies mites. 8-2. Identify the diseases of specific mite species. 8-3. Identify the management techniques used in the management of specific mites. 8-4. Identify the life cycles of hard and soft ticks. 8-5. Identify the diseases caused by specific species of ticks. 8-6. Identify the management techniques for ticks.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 8

BIOLOGY, IDENTIFICATION AND MANAGEMENT OF TICKS AND MITES

Section I. MITES

8-1. INTRODUCTION

Mites and ticks are in the class Arachnida, as are other important arthropods such as spiders and scorpions. The order Acarina (mites and ticks) differs from other arthropods in that the body is not segmented; the cephalothorax and abdomen are fused to form one body region.

Mites are usually small, and the hypostome is not exposed or armed with teeth or hooks.

8-2. MITES

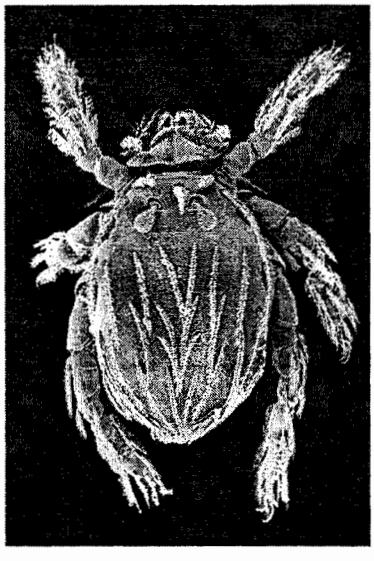
Mites are distributed worldwide. There are over 200 families, many being parasitic on plants and animals. The parasitic forms produce dermatitis, often followed by allergic reactions. Some species are etiological (direct) agents of mange and scabies. Species in the Genus *Trombicula* vector scrub typhus, a rickettsial disease. Mites also vector rickettsialpox, a disease of mice that is transmitted to people by mite bites.

8-3. GENERAL DESCRIPTION AND BIOLOGY

Mites may be free living or parasitic. Their habitats range from plant galls, rubbish, soil, fresh and seawater to humans and other animals.

- Many species are so small they require magnification to view.
- Adults and nymphs have four pairs of legs, but larvae have only three pairs.
- Many species lay eggs, but some retain the eggs within the body and give birth to larvae (ovoviviparous).
- The life cycle is often short, 2 - 3 weeks, so mite population size can increase very quickly under favorable conditions.

8-4. CHIGGER MITE (TROMBICULIDAE)



a. Life Cycle. These mites feed on humans only in the larval stage.

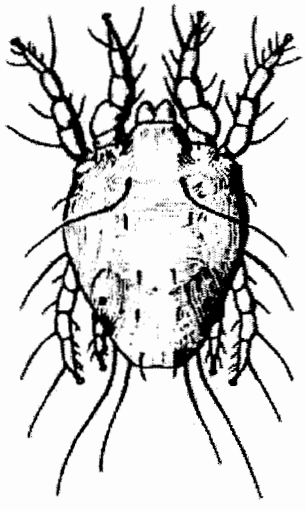
- They feed primarily in body areas where clothing is restricted such as ankles, waistlines and armpits.
- Generally, larvae feed once on lymph and partially digested skin tissue, but not blood. Engorgement takes about 3 days, but mites feeding on humans are usually knocked off much sooner.
- Nymphs and adults feed on the eggs and young of various arthropods such as Collembola eggs.
- In most of the U.S., there are one to three generations a year depending on the season or latitude, but breeding may be continuous on the Gulf coast and in Florida.

b. Hosts. Chiggers feed on a wide variety of animals including arthropods, snakes, turtles, birds and small mammals as well as humans.

c. Disease Transmission. American species do not transmit disease, but in Asia, chiggers are important vectors of scrub typhus.

d. Attachment. Chiggers don't burrow into the skin as is commonly believed. The host's skin becomes hardened and a tube called a stylostome is formed in which the chigger lies and feeds. By the time humans start itching, the chigger itself has usually dropped off the host.

8-5. HOUSE DUST MITES (*DERMATOPHAGOIDES* SPP.)



House dust mites can be a problem in any building people occupy on a regular basis. These tiny mites are barely visible to the naked eye.

a. Location. They're generally found in mattresses, pillows, overstuffed furniture, rugs, floors and other protected places where

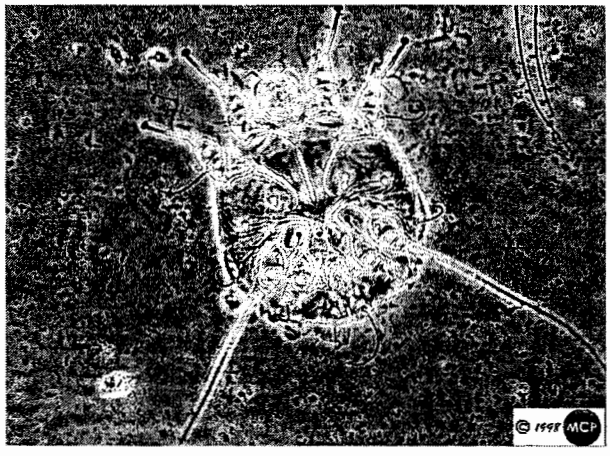
people sleep or sit for long periods. These mites need a damp environment and are often found along cracks in floors where moist air may enter a room.

b. Life Cycle. Eggs are laid singly and the life cycle takes about a month.

c. Food Source. These mites feed on a wide variety of foods, including dog food, cereals, yeast and ground beef, but they depend most heavily on shed skin scales of people and their pets.

d. Humans and Dust Mites. The minute mites become airborne easily and can be inhaled. Some people are allergic to mites or a chemical they produce which can cause an asthma-like reaction.

8-6. SCABIES MITE (*SARCOPTES SCABIEI*)



a. Identification. This very tiny mite has an oval body, is saclike in shape, and has a finely wrinkled body surface. Scabies mites are permanent parasites, spending their entire life on the host. The female burrows beneath the epidermis and lays eggs in her tunnels. Males burrow to a lesser extent and larva usually move into hair follicles.

b. Hosts. Scabies mites infest humans and a wide variety of mammals (causing sarcoptic mange). Although the species is the same, mites from one host species do not readily infest another.

c. Transmission. Transmission occurs through close human contact. No disease transmission occurs, but tunnels may become secondarily infected.

d. Characteristics of Bites on Humans. Scabies mites commonly occur in tiny papules, particularly in the webbing between fingers and folds of the wrist.

- An infestation may progress considerably before people are aware of it because new infestations do not usually itch.
- Intense itching usually occurs after one month. This itching, caused by toxic secretions and excretions, is associated directly with the burrowing.

8-7. SURVEY METHODS

Survey methods vary with the habits of the species being investigated.

a. Survey for Chigger Mites. Place 12- inch squares or circles of black paper or plastic on the ground for one to five minutes. Painted coffee can lids are very effective.

- Use an insect repellent before starting the survey to prevent personal attacks.
- Locate plates about 100 feet apart and use enough to generally cover the area being surveyed. If possible, heat the plates in the sun prior to placement to enhance attractiveness.
- When enough time has passed (10-15 minutes), observe plates for mites and record the total number counted. Chiggers will be small, reddish, and usually very active.
- If the area is very large, conduct surveys in grid areas approximately 400 X 400 feet in size. Establish grid areas at each corner and in the center to represent the entire area.

b. Survey for Scabies Mites. Apply ink to skin to stain burrows or identify mites from skin scrapings.

c. Collecting Mites. Collect mites in vials of alcohol using a fine pointed brush for later identification by a supporting laboratory.

- Use Berlese funnels to collect flour and grain mites and other free-ranging species, such as bird mites in nesting material.

d. Estimating Mite Population Densities. Estimates of chigger, bird, and rodent mite population densities can be based on data gathered by:

- Stunning or killing animal ectoparasites (with ether or chloroform) on dead or trapped animals, and combing the parasites from the animal into a white, enameled pan.
- Placing the live host animal in cages that have wire or hardware cloth bottoms so that any mites that drop off after engorging will fall into a pan of water put under the cage.
- Placing a dead host animal in a glass jar containing water and a detergent. The jar is shaken thoroughly to separate ectoparasites from the animal. The liquid is then poured into a funnel containing filter paper. Any mites will be strained out on the paper.

8-8. MANAGEMENT

Mite management is based on a combination of common sense, individual protective methods, sanitation and chemical control.

a. Common Sense. The common sense element is simply to avoid field exercises and other activities where mites are a problem, if possible.

b. Sanitation. Basic sanitation is fundamental both for immediate and long-term mite management. Chigger management depends on environmental modifications that allow sunlight and air to circulate freely, drying up habitats where the tiny, delicate chiggers live. Towards this end, cut lawns closely and eliminate tall weeds, shrubs and brush.

c. Chemical Control. In areas where troops must sleep on the ground, apply a residual spray shortly before they occupy the area.

d. Personal Protective Measures. The use of PPM will reduce the risk of chigger bites when missions and duties require entry into infested areas. Tuck trousers into socks or boots. Tuck shirts into trousers. Use the DOD Arthropod Repellant System (DEET on skin, permethrin on clothing, and proper wear of clothing).

e. Specific Mites.

- Rat and house mouse mite management is mainly based on ectoparasite dusting followed by rodent reduction to eliminate hosts.
- Bird mite management primarily depends on modifying buildings so birds can't enter.

Section II. TICKS

8-9. INTRODUCTION

Ticks are bloodfeeding ectoparasites of vertebrates. They are annoying pests and vector many diseases. Their bites are irritating, and if they are removed forcibly, the mouthparts frequently remain in the skin, possibly resulting in a sore, an infection, or blood poisoning.

a. Transmitters of Diseases. Ticks transmit a variety of diseases, such as:

- Lyme disease
- Tick-borne typhus (Rocky Mountain spotted fever)
- Tularemia
- Relapsing fever
- Tick-borne encephalitides
- Human ehrlichiosis
- Hemorrhagic fevers
- Tick paralysis

b. Ticks - Ectoparasites of Vertebrates. Ticks are blood-sucking ectoparasites of vertebrates, although many

species do not stay on the host after feeding and are essentially free-living organisms.

c. Two Families of Ticks. There are two families of ticks:

- the *Ixodidae*, or hard ticks.
- the *Argasidae*, or soft ticks.

SOME IMPORTANT TICK SPECIES

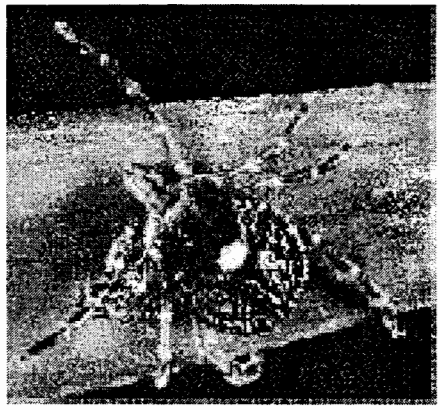
- Ixodidae (hard ticks)
  - -- Lone Star tick
  - -- American Dog tick
  - -- Rocky Mountain
  - -- Wood tick
  - -- Deer tick or black-legged tick
- Argasidae (soft ticks)
  - -- Relapsing Fever tick
  - -- Fowl tick

8-10. IXODIDAE (HARD TICKS)

Members of this family are called hard ticks because they have a hard dorsal surface called a dorsal shield or scutum. This shield covers the entire back of the male, but only partly covers the female.

- Hard ticks have mouthparts readily visible from above, if not engorged with blood.
- They attach themselves firmly to their hosts for blood-feeding and may remain there for weeks before they're through feeding.
- Hard ticks typically take one blood meal in each of the three developmental stages - larva, nymph, and adult.
- Most species feed on a different host during each stage.
- Larval ticks are very small and have six legs. Nymphs and adults have 8 legs and differ in size and reproductive maturity.
- American dog ticks, as well as other species, are attracted to the scent of animals, so they are most numerous along roads, paths and trails.

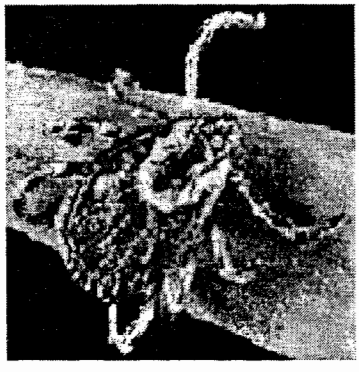
8-11. LONE STAR TICK (*AMBLYOMMA AMERICANUM*)



This tick is a vector of tick-borne typhus, tularemia, and human ehrlichiosis.

- Its easy to recognize females by the conspicuous silver-white spot at the tip of the scutum.
- Males have pale markings that are more diffuse.
- In the southeastern U.S., it infests deer, cattle, dogs, and birds, and will readily bite people while in the larval, nymphal and adult stages.
- Its bite is quite painful and may itch for a long time.

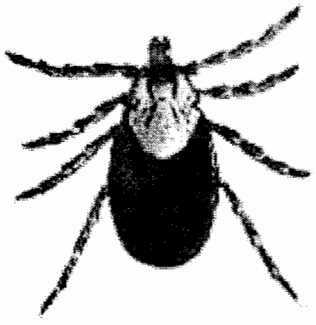
8-12. AMERICAN DOG TICK (*DERMACENTOR VARIABILIS*)



This species is widely distributed east of the Rocky Mountains and the Pacific coast.

- Dogs are its preferred host, although it feeds readily on many large mammals.
- Adults are commonly found in grass and other low vegetation.
- Males remain on the host for an indefinite time period, alternately feeding and mating.
- Females mate, feed, become engorged and drop off to lay several thousand eggs.
- This species is the principal vector of tick-borne typhus in the central and eastern U.S.

8-13. ROCKY MOUNTAIN WOOD TICK (*DERMACENTOR ANDERSONI*)



This tick is common in the Rocky Mountain states and in southwestern Canada.

- Larvae and nymphs attack small mammals and adults obtain their blood meals from large mammals, including people.
- This tick also is a vector of Rocky Mountain spotted fever and is the principal vector of the disease within its range. It also transmits Colorado tick fever.
- It closely resembles the American dog tick, but adult wood ticks have more pale coloring and larger goblets (circular markings) on the spiracular plates.

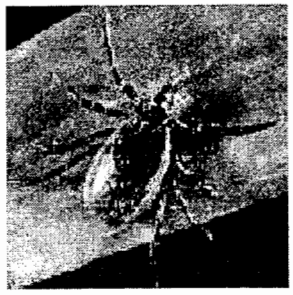
8-14. DEER TICKS

This name is commonly attached to two different genera of ticks.

a. *Dermacentor albipictus*. *Dermacentor albipictus* is also called the "winter tick" or the "elk tick' and is widely distributed in North America.

- This one-host tick does not attack in the summer; larvae seek a host after colder temperatures occur.
- Large populations may cause the death of deer and elk through blood loss and subsequent loss of vitality.
- People are normally attacked only when they are dressing or otherwise handling infested game animals.

b. *Ixodes*. Members of the genus *Ixodes* are commonly called "deer ticks" or "black-legged ticks" and are the principal vectors of Lyme disease within their respective geographical areas.



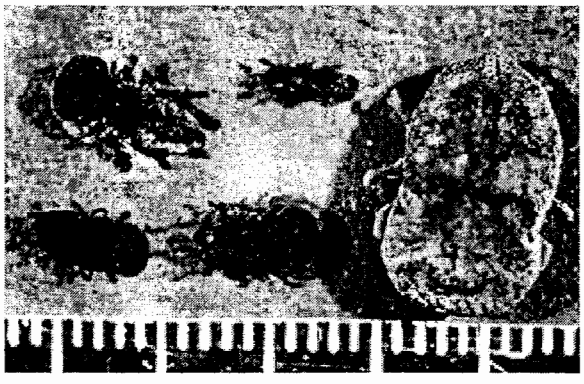
- Lyme disease is a spirochete infection transmitted by the bite of two species of ixodid ticks, *I. pacificus* in the western U.S., and *I. scapularis* in the eastern U.S.
- This disease begins as a skin rash and fever and can progress to cause debilitating arthritis of the large joints.
- These ticks prefer habitats such as wooded areas and adjacent grasslands.
- They feed on a variety of hosts like birds, mice, deer, domestic animals, and people.

8-15. ARGASIDAE (SOFT TICKS)

Soft ticks don't possess a scutum or dorsal shield. Because they lack this shield, the two sexes look alike.

- Their mouthparts are beneath the anterior end of the body and are often not visible from above.
- Principal hosts of Argasids are birds, domestic animals, bats and small mammals.
- These ticks feed intermittently at night.
- An adult female lays small batches of eggs following each of several blood meals, producing 500-1000 eggs in her lifetime.
- Some species resemble bed bugs in their habits of feeding at night and hiding during the day.

8-16. RELAPSING FEVER TICKS (*ORNITHODOROS* SPP)



This is the most important genus of soft tick from a medical standpoint.

- Relapsing fever ticks are seldom seen by the average person since they mainly live in nests, caves, and burrows and can survive starvation for months or even years.
- People are occasionally bitten and may contract relapsing fever as a result.

8-17. FOWL TICK (*ARGAS PERSICUS*)

This tick is a vector of fowl spirochaetosis, and is commonly called the "blue bug". It is a parasite of wild birds and poultry, primarily in arid areas.

- It feeds at night and becomes engorged in less than an hour.
- After feeding they seek shelter in cracks and crevices where females deposit their eggs.
- Eggs hatch in about 2 weeks and the six legged larvae find a host and attach themselves.
- After feeding for about 5 days, they drop off, molt, and become nymphs.
- The nymphs feed, molt and go through two or three stages before they become adults.
- Like the relapsing fever tick, these ticks may live for months or years without blood, awaiting an opportunity for a blood meal.
- It readily attacks people but does not transmit human disease.

8-18. SURVEY METHODS

There are two common ways to survey for ticks. The most widely used is the tick drag method.

a. The Tick Drag Method. A tick drag is simply a white flannel panel about 4 feet square attached to two wooden dowels and has a four- to five-foot length of rope attached to each end of one dowel.

- To use it, simply drag the panel through the area being surveyed for a predetermined distance, such as 100 paces.
- Always try to drag it the same distance through the same areas so counts and species can be compared.

- Always check yourself for ticks every time you check the drag cloth.

b. A Second Method. The second method also involves the use of a 4 foot flannel square.

- To use this technique, place the cloth on the ground; in the center, place a person, caged animal, or dry ice.

- After a predetermined period of time, count the number of ticks present.

8-19. MANAGEMENT

The techniques of tick management are very similar to techniques for managing mites.

- Like mites, ticks can be a problem in the field or in established quarters on an installation.

  -- In the household, they are most commonly associated with pets.

  -- In the field, ticks can be important disease vectors or nuisances.

- Individual protective measures are the first line of defense against tick infestations; apply them the same way as for mites.

- Other similarities with mite management include avoiding known infested areas when possible, area vegetative management, and the use of residual pesticide treatments in areas where troops hold exercises.

- Like mites, ticks are normally found in areas where their primary hosts live, rest or feed, having dropped off their host after engorging with blood.

  -- When they need another blood meal, they climb vegetation and attach to the first suitable warm-blooded host that comes along.

- Brown dog ticks are often serious pests in urban backyards, kennels, and occasionally indoors. Vegetation management has little impact on this species.

  -- Use crack and crevice treatments with a residual spray for this tick.

- Today, there are excellent insect growth regulators available for use against ticks in quarters. Effective veterinary products are also available for household pets.

EXERCISES, LESSON 8

REQUIREMENT. Answer the following questions by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. The disease Asian chigger mites transmit is _____.

2. House dust mites or chemicals they produce can cause _____ reaction in some people.

3. Where does the female scabies mite burrow and lay her eggs? _____
_____

4. Troops must sleep on the ground in an area where there are mites. What mite management technique should be used? _____
_____
_____

5. Bird mites can be managed by _____
_____
_____

6. List four diseases ticks can transmit.

   a. _____

   b. _____

   c. _____

   d. _____

7. The Lone Star tick transmits the diseases _____, _____ and _____. The female Lone Star tick can be readily identified by the _____.

8. The principal vector of tick-borne typhus in the U.S. is the _____.

9. Lyme disease, transmitted by deer ticks begins as a skin rash and can progress to cause _____ and _____.

10. List three methods of managing ticks.

    a. _____

    b. _____

    c. _____

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LESSON ASSIGNMENT

LESSON 9	Stored Products Pests.
LESSON ASSIGNMENT	Paragraphs 9-1 through 9-27.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to employ integrated pest management principles to control stored-product pests IAW DOD 4145.19-R-1, TM 5-632, MIL STD 904A, TIM 11, *Hydrogen Phosphide Fumigation with Aluminum Phosphide*, TIM 27, *Stored Products Pest Monitoring Methods*, and AFPMB *Military Pest Management Handbook*.
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the references listed above, you should be able to: 9-1. Identify the correct action for handling insect species specimens and a variety of insect infestations infesting stored products. 9-2. Identify the condemnation levels for insects infesting stored food products. 9-3. Identify the personnel who are qualified to inspect food supplies. 9-4. Identify the corrective measures to be used for the control of stored products pests.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 9

STORED PRODUCTS PESTS

Section I. FOOD PESTS

9-1. INTRODUCTION

Stored products pests are a major insect pest problem aboard ships and at military installations worldwide. These insects destroy a wide variety of products derived from or composed of materials of plant and animal origin. Most damage occurs while materials are in storage, but infestations may begin in the field, at the processing plant, during shipment or storage.

There are three main types of stored products pests: food, animal fiber, and wood products.

9-2. FOOD PESTS

These pests destroy by contaminating far more than they actually eat. The most extensive losses result from grain and cereal product infestations by several species of moths, weevils and beetles. Other commodities such as beans, peas, dried fruits, spices, seeds, tobacco and candy also become infested. Bagged pet foods are among the most commonly infested food items and often become a source of infestation for other food items stored with them, especially in warehouses where sanitation is lacking.

a. Animal Fiber Pests. Moths and beetles destroy unprotected products made in whole or in part of hides, wool, mohair, fur, hair, feathers, down and animal bristles.

b. Wood Product Pests. Termites, various beetles and wood-decaying fungi destroy wood products in storage. Some items most frequently attacked are lumber, tool handles, pallets, crates and furniture.

9-3. IMPORTANCE

a. Economic Costs. Losses from stored products pests cost the military millions of dollars each year. These losses occur not only from the direct cost of destroyed products, but also from replacement and transportation costs for shipping new supplies, often to foreign countries.

b. Impact on the Military. The impact these pests have on contingency operations is probably second in importance only to disease vectors. Stored products pests can pose a much greater problem to the military than to the civilian community for two reasons.

- First, many military operations occur overseas, so infestible goods must be shipped over much longer distances. Goods in transit are common sources of stored product infestations.
- Second, the military must store great quantities of infestible products for long periods of time, often under adverse environmental conditions. Thus, an infested pound of flour discarded halfway around the world is much more expensive than a pound of infested flour in a local supermarket.
- For these reasons, it's critical to maintain an aggressive, effective, and consistent stored products pest management program.

9-4. INSECT INFESTATION/ CONTAMINATION -- CONDEMNATION LEVELS

a. When One Condemns the Lot. When a product contains all or part of any living or dead insects belonging to the genus *Trogoderma* or other dermestid beetles, one insect within the product itself (not external) shall be justification for the condemnation of the lot. Warehouse and Khapra beetles are examples.

b. When Three or More Per Pound Condemns the Lot. When a product contains living or dead insects belonging to the genus *Tribolium* (flour beetles), an average of three insects or more per pound of product, in the lot being inspected, shall be justification for condemnation of that lot. Red and Confused flour beetles are examples.

c. When Seven or More Per Pound Condemn the Lot. When a product contains insects other than those belonging to the genus *Trogoderma* (or other dermestids) or *Tribolium*, an average of seven or more living or dead insects per pound of product, in the lot being inspected, shall be justification for condemnation of that lot. Indian meal moths and Rice weevils are examples.

CONDEMNATION LEVELS
# of insects required in product to condemn entire lot

1 insect (all or part)	3 insects per pound	7 insects per pound
Dermestidae (*Trogoderma* spp.)	*Tribolium* spp.	All others

Section II. COMMON STORED-PRODUCT PESTS

9-5. DERMESTID BEETLES: WAREHOUSE BEETLE (*TROGODERMA VARIABILE*)

Warehouse beetle

a. Impact on Humans. The warehouse beetle possibly has the most adverse impact on food because of the barbed setae that cover the larva's body. A single larva has thousands of these setae that break off and contaminate the food it infests. When people eat contaminated food, these setae enter the intestinal lining and cause dysentery and diarrhea. This is why military standards require that food products infested by warehouse beetles be destroyed.

b. Products Infested. The warehouse beetle infests a wide range of food products, both raw and processed. The adult can penetrate packaging film, even MREs. It's the most common of all *Trogoderma* species collected from processed foods, such as beans, flour, cornmeal, cocoa, breakfast cereals, cookies, and many other items.

c. Development. Adults are oval and normally black with variable patterns of dark, reddish brown blotches. They range in length from 1/10 to 1/6 inch. Eggs are laid in or on food items. Larvae are yellowish brown in color and covered with the long barbed setae described above. They normally feed for about one month before pupating. The last larval instar can go into diapause for several months if conditions warrant.

d. Identification. Only a highly trained, well-equipped technician or entomologist can identify these beetles because many species of *Trogoderma* infest stored food products, and both larvae and adults look very similar. Therefore, pest managers who suspect an infestation by *Trogoderma* species should send specimens to experts for identification

9-6. DERMESTID BEETLE: KHAPRA BEETLE (*TROGODERMA GRANARIUM*)

a. Impact. The major reason khapra beetles are so destructive is that under the proper conditions they reproduce more rapidly and in greater numbers than do other stored products insects. For this reason and because of the quarantine action that must be taken, any suspected *Trogoderma* species found in products imported from a foreign country should be killed immediately by fumigation, and specimens should be sent to the nearest supporting laboratory for identification.

b. Products Infested. Larvae feed on damaged grain and cereal products but will also feed on in dried insects, dead mice, and dried blood.

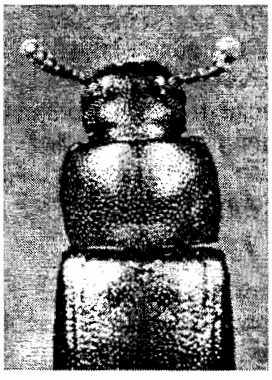
c. Location. The khapra beetle is a common pest in India and many other parts of the world. In the U.S., it was first detected in California in 1953.

- Since that time, a massive and expensive eradication program undertaken by the USDA has eliminated the khapra beetle in the U.S.
  - -- It's one of the major targets of the USDA's Animal and Plant Health Inspection Service (APHIS) quarantine efforts at all major CONUS ports of entry.
  - -- The USDA requires total elimination of the pest, and this usually involves both a quarantine against movement of potentially infested product and whole building fumigations.

- Infestations must be reported to the USDA.

d. Identification. The adult is 3 mm long and pale to dark brown or black in color. Larvae are tan and cream in appearance and have numerous setae. This makes them look much like other *Trogoderma* species which are commonly misidentified as the khapra beetle.

9-7. TRIBOLIUM BEETLES - RED AND CONFUSED FLOUR BEETLES (*TRIBOLIUM CASTANEUM* AND *T.CONFUSUM*)



Red flour beetle

Confused four beetle

a. Impact. These insects are among the most common pests found in cereal products such as flour and meal and are two of the worst insect pests of prepared cereal products.

b. Products Infested. They're general ceral product feeders and also infest peas, beans, nutmeats, dried fruits and spices. Both beetles are shiny and reddish brown.

c. Location. These beetles are found throughout the world wherever grains and grain products are stored.

d. Development. The life cycle takes about six weeks during the summer.

- The eggs are deposited loosely in flour and other processed cereal grain products.
- Eggs are covered with a sticky solution so they become coated with flour and bran; they hatch in 5 to 12 days.
- Full grown larvae pupate when they're about 3/16 inch long.
- Pupae are naked, having no cocoon or other covering.

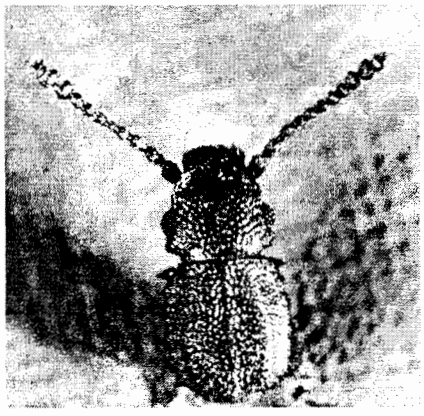
e. Identification. The only distinguishing characteristics between the two species are that the red flour beetle can fly but the confused flour beetle can't, and the last 3 segments of the red flour beetle's antennae enlarge abruptly to give it a club appearance, while the confused flour beetle's antennae enlarge gradually.

f. Pheromone. Siftable food infested by only a few of these insects (fewer than three insects per pound) can be reprocessed or cleaned by screening with fine silk bolting cloth.

- These beetles use pheromones both as sex attractants and as an alarm system.
- When under stress, such as a sudden change of temperature or fumigation, these insects release pheromones, causing additional contamination of food.
- If beetle populations are high, these pheromones can impart a very disagreeable odor and adversely affect taste and baking qualities of products like flour.
- There is no way to remove pheromones from infested commodities; moreover, benzoquinones excreted by these insects have been found to be carcinogenic in small quantities.

Section III. OTHER STORED-PRODUCTS PESTS

9-8. SAW-TOOTHED GRAIN BEETLE (*ORYZAEPHILUS SURINAMENSIS*)



Saw-toothed grain beetle

a. Impact. This grain beetle is the most commonly reported pest infesting stored products in the United States.

b. Products Infested. This beetle infests grains and grain products such as flour and meal. It will also infest practically all foods of vegetable origin, including nutmeats, dried fruits, breakfast foods, sugars, drugs, spices and tobacco, even invading packages to find food.

c. Location/Life Cycle. This beetle is found throughout most of the world. In the summer the life cycle is 3 to 4 weeks long. The female beetle drops her eggs loosely on food stuffs or deposits them in crevices in grain kernels where they hatch 3 to 5 days later. Larvae crawl actively as they feed on available food. when full grown, they're about 1/8 inch long. To pupate, they form cocoon-like structures by cementing together fragments of grain and other foods. Adults normally live for 6 to 10 months.

d. Identification. Six saw-tooth-like projections on each side of the thorax make identification easy.

9-9. CIGARETTE BEETLE (*LASIODERMA SERRICORNE*)/ DRUG STORE BEETLE (*STEGOBIUM PUNICEUM*

Cigarette beetle

Drugstore beetle

a. Products Infested. The cigarette beetle is a major pest of tobacco but also infests several different foods and other materials such as dry yeast, spices, dried fruits, grains, cereal products, seeds, books, woolen fabrics, silk, leather, dried meats, upholstered furniture and even pyrethrum insect powder.

b. Location. These beetles are found throughout tropical, subtropical, and temperate parts of the world.

c. Identification. These robust little beetles are about 1/10 inch long with an oval shape and reddish-yellow color. The head is bent down at a right angle to the body, giving a humped appearance when viewed from the side.

9-10. LESSER GRAIN BORER (*RHYZOPERTHA DOMINICA*)

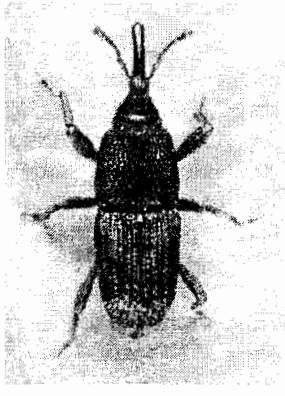
Lesser grain borer

a. Products Infested. This small beetle infests many whole grain products as well as flour and other grain derivatives. It has been found damaging books and wooden items, and some researchers believe it was originally a wood-destroying beetle. Both larvae and adults are destructive.

b. Identification. The adult lesser grain borer has a slender, cylindrical form and is about 1/8 inch long. It has polished dark brown to black color, with a roughened surface and small pits on the wing covers. The head is turned under the body and has strong jaws which can cut through wood and other vegetable material.

9-11. RICE WEEVIL (*SITOPHILUS ORYZAE*)

Pupa



Adult

Rice weevil

a. Impact. This weevil mainly infests whole grain and is the most destructive of all pests of stored grains. It has been a pest on military installations for years.

b. Products Infested. In addition to whole grains, At times, it may also infest solid farina products such as macaroni and caked or compressed flour.

c. Identification. The adult weevil is a small snout beetle rarely over 1/8 inch long The adult weevil is reddish-brown to black, usually with four light reddish to yellowish spots on the back. Its thorax is densely pitted with round punctures. It is a good flyer.

9-12. Granary weevil (*Sitophilus granarius*)

Granary weevil

a. Impact. The rice weevil and the granary weevil are oftent found together, but the granary weevil is a more serious pest in northern climates.

b. Products Infested. These beetles infest whole grains.

c. Identification. It resembles the rice weevil in the food it attacks, in it size and color, and in its life cycle. Granary weevils can't fly, unlike the rice weevil. Granary weevils move from one location to another along with infested grains. The thorax is marked with longitudinal punctures rather than the round punctures found on the rice weevil.

9-13. COMMON BEAN WEEVIL OR COW PEA WEEVIL (*ACANTHOSCELIDES OBTECTUS*)

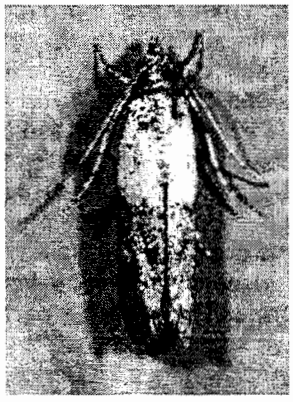
Common bean weevil

a. Products Infested. This weevil infests beans in storage as well as those growing in fields. It breeds continuously in dried seeds in warm places so all stages may be found under winter storage conditions and during the summer.

b. Location/Life Cycle. The common bean weevil is found throughout the U.S. The life cycle takes 3 to 12 weeks. The adult female weevil lays her eggs on pods in the field or oviposits on stored beans. After hatching, the larvae enter the beans where they eat out cavities. The weevils pupate in cells near the surfaces of the beans. Adult beetles don't feed on beans. In unheated storage areas in cold weather, these beetles will hibernate in the adult stage.

c. Identification. This weevil is about 1/8 inch long and its body narrows evenly toward the head. It's light olive brown to gray in color, mottled with darker brown and gray. The appendages are reddish.

9-14. INDIAN MEAL MOTH (*PLODIA INTERPUNCTELLA*)



Indian meal moth

a. Products Infested. This moth infests broken grain and cereal products. It prefers coarse grades of flour and milled products to the more highly refined grades, but also infests a wide variety of dry food products, including dried fruits, nuts, graham crackers and powdered milk.

b. Life Cycle. In warm weather the life cycle is completed in 4 to 8 weeks. The female places her eggs on the product surface. The larva leaves a silken thread wherever it crawls through or over food and this forms a loose webbing easily found in heavy infestations. Infestations result in a mat-like mass of moist decomposing food and webbing. When fully grown, the ½ inch long larva pupates in a silken cocoon.

c. Identification. Indian meal moth is easily recognized by its distinctive markings on the forewings, which are reddish brown with a coppery luster on the outer two-thirds and whitish-gray on the inner third. The adult moth has a wingspan of about 3/4 inch.

9-15. MEDITERRANEAN FLOUR MOTH (*ANAGASTA KUEHNIELLA*)

a. Products Infested. This insect infests flour and meal. It prefers cereal products, but also consumes many foods including whole grain, bran seeds, biscuits and dried fruit.

b. Life Cycle. The life cycle in 4 to 8 weeks. The female oviposits on the food surface. The larvae spin silken threads wherever they go which creates webs and mats together particles of the food product. When fully grown, the ½ inch long larvae may stay where they've been feeding or migrate to other parts of the warehouse. The larvae usually spin silken cocoons but may also pupate in cracks and crevices without cocoons.

c. Identification. The moth has a wingspan of a little more than one inch. Its fore wings are pale gray and have transverse wavy black markings which are often rubbed off.

9-16. ANGOUMOIS GRAIN MOTH (*SITOTROGA CEREALELLA*)

Angoumois grain moth

a. Impact. In heated warehouses, 10 to 12 generations per year may occur. Infestations in storage areas are most serious

where good housekeeping has been neglected and grains are openly scattered.

b. Products Infested. This moth infests whole grains, such as wheat, barley, rye, corn, oats, rice and various seeds.

c. Life Cycle. In warm areas the life cycle takes five to seven weeks. In cold areas, larvae overwinter in grain kernels and the life cycle may take up to six months. The female moth lays her eggs on the surface of grain kernels. Larvae enter kernels where they feed and develop. When a larva is fully grown, it cuts a circular opening through the seed coat and leaves a covering flap so the adult moth can emerge after pupation.

d. Identification/Location. The adult is a small buff or yellowish-brown moth with a wing span of about one inch. It's common throughout the world and is particularly damaging in tropical and subtropical areas.

Section IV. SURVEY METHODS

9-17. ALL SUBSISTENCE SUSCEPTIBLE TO DAMAGE

Virtually all items of subsistence, except canned foods, are susceptible to damage by insects, rodents, and other pests. Natural textiles are also susceptible. Stored products insects may attack woolens, mixed woolens, furs, feathers, felt, natural fibers and untreated hardwoods. This makes the pest manager's work critical, particularly when climate and other environmental conditions are conducive to growth, reproduction, and migration.

a. Visual Inspection. Visual inspection is needed as soon as supplies enter the warehouse or, preferably, before they are unloaded. If goods are heavily infested the lot should be rejected. However, if inspection shows only a light surface infestation, it may be possible to fumigate and salvage most of the product before storage. With food, the salvage potential depends on the pest involved and when the infestation was identified. All decisions should be made by local veterinary personnel according to guidance in MIL-STD-904B.

b. Inspections at Regular Intervals. Qualified personnel (Veterinarians/Veterinary Technicians) should inspect supplies in storage at regular intervals and at least monthly depending on the geographic region and time or year. Necessary equipment for these inspections includes a flashlight, magnifying glass, hand sifter, and bag tier to use in direct commodity inspections. Normally a 5% inspection will indicate the condition of the lot being inspected; spot inspections of any commodity need not exceed 10% of the lot.

c. Inspecting Sacked Foods. Infestations in sacked foods are usually advanced, and a visual inspection will often detect larvae and adult insects. But to detect early infestations, or if products are in multi wall bags, open the bag and sift sample lots of the contents. Randomly select, empty and sift containers of spices, pepper, dried milk and other finely divided subsistence items; look for evidence of beetles, moths, silverfish and other destructive pests. Also carefully inspect folds and seams of the bags themselves.

d. Pheromone Traps. In addition to these inspection measures, there are many types of pheromone traps. Before using these traps, obtain all available information about local stored product pests and the availability of appropriate traps. Outside a warehouse, these traps may be used as a indirect inspection tool to reduce the need to open commodities and that enable pest management personnel to track the presence of pests that have previously attacked commodities. As with pesticides, follow all label instructions for using these traps. Placement is particularly important since some pest fly while others do not and certain species may be found in specific areas in relation to the food product.

e. Consumer Complaints. This may be the least reliable, but also the first indication of a stored pest infestation. Ensure when identifying the pest you have a location on where the product was purchased. Do not complete the investigation with identifying the pest. Take the time to visit the Commissary or Post Exchange where the product was purchased. Report your findings to the responsible individual and the local Veterinary Food Inspector. One infested product may be an indicator of a bigger problem in the warehouse.

9-18. INSPECTION/FUMIGATION AISLES

It's important that inspection/fumigation aisles (including all walls) be maintained in food storage areas. Aboard a ship, small inspection aisles are sufficient since fumigation is conducted only when in port. Again, the use of pheromone traps for food pests are a valuable tool in detecting early infestations. Pheromone traps are available for most common flying food pests, including the khapra beetle. Inspect these traps on a regular basis.

9-19. CHECKING TRAPS/BAIT STATIONS

Use of electric grid traps for stored product pests alone is not recommended. But if they're already being used to control filth flies, they are an additional information source for stored product infestations. Check such traps at least weekly for the presence of flying stored pests and for *Trogoderma* spp. that often breed in dead

insect bodies caught in the traps. Also inspect rodent bait stations at least weekly since they can also be a food source for insect pests if traps aren't regularly attended.

Section V. MANAGEMENT

9-20. PREVENTIVE MEASURES

Proper preventive measures are essential to effectively manage stored product insects. These measures include:

- Purchase of insect-free products.
- Effective surveillance inspections.
- Minimizing storage periods for individual lots (first in, first out rotation).
- Preventive maintenance in storage depots.
- Use of insect-proof wrapping and containers.
- Storage at low temperatures.
- Use of fumigants and insecticide treatments.

9-21. PURCHASE OF INSECT-FREE PRODUCTS

All products purchased for military use should be inspected when they're purchased and again upon delivery to ensure no infested items are placed in military depots to infest clean stocks. Food processing plants having military contracts should be inspected periodically by trained observers.

9-22. INSPECTIONS

Inspections are the backbone of the military pest management program. They're the primary responsibility of the U.S. Army Veterinary Corps and U.S. Air Force Military Public Health Officers, but inspections are also the responsibility of storage and pest management personnel. These activities should routinely look for any abnormal situations that may indicate pest infestations. Additionally, joint monthly inspections by representatives of both activities are often very productive.

9-23. SHORT STORAGE PERIODS

Storage periods for military supplies should be as short as possible consistent with economics involved and normal depot operations. Under ideal conditions, early infestations of weevils, moths, beetles and other pests develop into large and destructive populations within a few months.

9-24. PREVENTIVE MEASURES IN STORAGE DEPOTS

a. Begin Outside. Preventive measures must start outside. One of the easiest and most basic preventive measures possible is to use proper lighting. For example, mercury vapor lamps attract flying insects, so their use should be avoided around food storage buildings and nearby parking lots. Instead, only use high pressure sodium vapor lamps, which don't readily attract flying insects in these locations. In either case, placement of lights on the storage building itself should always be indirect and not over entrances and doors (particularly if warehouse doors are often open at night).

b. Vegetation Around Warehouses/Storage Buildings. Vegetation around warehouses should not attract flying insects and should be maintained at least two to three feet away from warehouses. This provides a barrier strip between the vegetation and outside wall of a storage building where residual pesticides may be applied to control crawling pests, such as ants.

c. Cleanliness and Sanitation in Storage Areas. Basic rules of cleanliness and warehouse sanitation should be observed in all storage areas.

- All broken or torn containers should be promptly removed to a salvage area, and spilled foodstuffs must be discarded.
- Accumulations of bits of subsistence items, woolen lint and similar materials in cracks will support the growth of stored product insects.
- Animal foods should be isolated from cereal products and dried fruits and if possible stored in a separate building.
- Precautions against insects in meat storage areas include proper disposal of trimmings and frequent floor scrubbing.
- Interiors of freight cars, trucks and other conveyances should be insect-free before they're loaded.
- If a conveyance cannot be made insect-free or easily fumigated, it must be rejected.

9-25. USE OF INSECT PROOF CONTAINERS

Properly sealed containers provide protection for subsistence items and other packaged goods.

- Metal and glass containers give food total protection against outside infestations.
- Flour, beans, peas, and rice are greatly protected by shipment in multi-walled paper bags with tight end closures.
- Inner liners may be treated with an approved insecticide, to protect the product against insect infestation for up to 12 months.

9-26. STORAGE TEMPERATURES

Full advantage should be taken of climatic conditions to expose stored items to low temperatures if such exposure will not injure the goods.

- Storage at temperatures of 50°F and below will arrest development and feeding of most storage pests.
- Most stored products pest will not produce eggs even at slightly higher temperatures.
- At 40°F essentially all development stops as the insects die or enter diapause.
- However, low temperatures aren't a cure for stored products pests; a product must be maintained at -5°F for a week to kill all stages (including the eggs) of some species.
- In warm climates and during summer months, goods should be stored under dry conditions whenever possible.
- Insects in stored products tend to develop at a faster rate when these products have high moisture content.

9-27. INSECTICIDAL TREATMENTS

a. Residual Sprays. Insecticide sprays are often used to give residual protection to non-infested stocks in storage, consistent with service regulations on preventive pesticide applications. Pesticide applications are generally restricted to crack and crevice treatments. Check pesticide labels regularly since use restrictions may change. Always treat shipping containers prior to loading. Also, conduct residual treatments of warehouses before products go into storage.

b. Space Treatments. Space treatments using nonflammable formulations in ULD aerosol generators prevent the start and spread of insect infestations in storage warehouses. When temperatures are above 60°F, food warehouses may be treated at about 30 day intervals.

c. Fumigants. Fumigating commodities in storage is a fast, direct, and effective way to eliminate all stages of living insects in stored products. Fumigating is the only pesticide procedure that will kill pests inside of packaging and permit salvaging of the package contents.

(1) Phosphine fumigation. Fumigation with phosphine (hydrogen phosphide gas) is widely used. It leaves **NO** residue in foods. Phosphine may be used for stack fumigation in a warehouse without closing down the facility and is the only type of fumigant approved for use in moving rail cars.

(2) Rail car fumigation. Shippers are normally required to use rail car fumigation during the summer months for shipments from a manufacturer to the military and between military installations. This is why all military installations that receive rail car shipments of subsistence need a trained two-person fumigation team equipped to conduct and clear such rail car fumigations, as well as normal stack fumigations.

EXERCISES, LESSON 9

REQUIREMENT. Answer the following questions by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. List the three main groups of insects that infest stored products.

   a. _____

   b. _____

   c. _____

2. Some species of moths and beetles are animal fiber pests. What do they destroy?

   _____
   _____
   _____
   _____

3. Items most frequently attacked by _____ pests include lumber, tool handles, pallets, crates, and furniture.

4. The _____ weevil, a pest on military installations for years, is the most destructive of all pests of stored grains. This weevil also infests macaroni and caked or compressed flour.

5. Why does the dermestid warehouse beetle probably have the most adverse impact on food?

_____

_____
_____
_____
_____
_____

6. Inspections on military installations are the primary responsibility of the _____ _____ and the _____ _____.

7. List four preventive measures to take to control stored products pests.

a. _____
_____

b. _____
_____

c. _____
_____

d. _____
_____

8. *Triboleum* beetles use scent pheromone both as _____ and _____.

9. List two reasons why stored products pests are a greater problem to the military than to the civilian community.

a. _____
_____
_____

b. _____
_____
_____

10. How can pheromones be removed from tribolium beetle infested flour?

_____
_____

LESSON ASSIGNMENT	
LESSON 10	Biology and Management of Ants and Miscellaneous Household Pests.
LESSON ASSIGNMENT	Paragraphs 10-1 through 10-15.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to identify and manage ants and other household pests IAW AFPMB *Military Pest Management Handbook*, and Pest Control Technology, *Field Guide for the Management of Structure-Infesting Ants*.
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the references listed above, you should be able to: 10-1. Select the two distinct morphological characteristics that are used to identify ants. 10-2. Identify the key characteristics of the species of ants discussed. 10-3. Identify the three management techniques used in ant management. 10-4. Identify the diseases that Conenose (kissing) bugs transmit. 10-5. Identify control measures for bed bugs. 10-6. Identify the food habits of silverfish and firebrats. 10-7. Identify management techniques for silverfish, firebrats, field crickets and boxelder bugs.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 10

BIOLOGY AND MANAGEMENT OF ANTS AND MISCELLANEOUS HOUSEHOLD PESTS

Section I. ANT BIOLOGY

10-1. INTRODUCTION

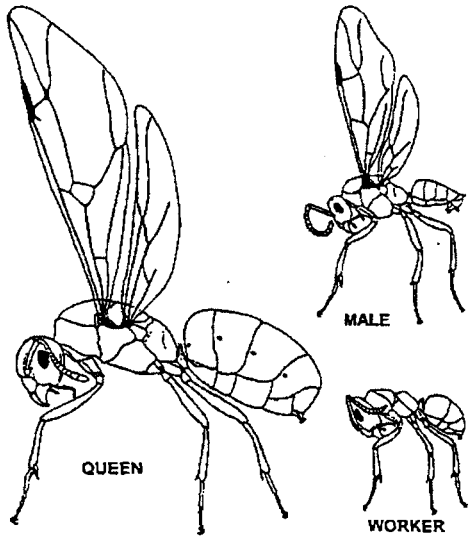
Ants are one of the most numerous types of animals on earth. Given their widespread distribution, characteristics, and appearance, they are easily recognized. Ants are members of the Order Hymenoptera with wasps and bees, and are in the Family Formicidae.

10-2. GENERAL ANT BIOLOGY

a. Ant Abdomen and Antenna. Ants have two distinct morphological characteristics that make them easily identifiable. One of these is the separation of the abdomen into two distinct regions - a slender one or two-segmented, freely moving pedicel, and a larger, more compact terminal portion called the gaster. The other characteristic is the elbowed antenna, in which the first segment (scape) is greatly elongated in both the female and worker. In males, antennae often don't appear to be elbowed, since the scape isn't always noticeably lengthened.

Ant morphology

b. Ant Castes. There are at least three distinct castes of ants: workers, queens, and males. Males usually have wings, which they retain until death. Queens, the largest of the three castes, normally have wings but lose them after mating. Workers are wingless females.



c. Ant Life Cycle. Ants undergo complete metamorphosis and therefore have egg, larva, pupa and adult stages.

- Ant eggs are almost microscopic in size and of various shapes, depending on the species.
- Upon hatching, soft, legless larvae are produced.
- One of the more common larval forms is more or less translucent, gourd or squash shaped, with the head at the narrow end.
- Pupae resemble adults in form but differs in being soft, unpigmented and lacking mobility.

d. New Colonies. Ants establish new colonies in a number of ways.

- One is a process known as splitting or budding, in which a fertilized daughter of the queen leaves the parental nest accompanied by a number of sister workers who help establish and carry on the functions of the new colony.
- Another method is a form of parasitism in which a fertilized female or queen of one species seeks, and may obtain, adoption in a colony of another species that doesn't have a queen.
- A third method is for a fertilized female to construct or enter a preformed cell or cavity in wood, in the ground, or under bark of a stump or log, close the chamber, and rear her first brood.

10-3. FIRE ANTS (*SOLENOPSIS* SPP.)

These ants are extremely pugnacious and are called fire ants because of their sharp, burning stings. Of special importance is the red imported fire ant, *Solenopsis invicta*, which was introduced into the U.S. in the 1940s and has become extremely important in the southern United States. This ant builds large, hard-crusted earthen mounds. It stings by first sinking it powerful mandibles into the flesh for leverage and then driving its stinger into the victim. Multiple stings are common and may require medical

attention. This ant not only damages crops but will also kill and devour newly hatched quail and poultry, or enter pipped eggs to reach the unhatched chicks. It will also attack young pigs, newly born calves, and other small animals. Other fire ants of some importance are the black fire ant, *Solenopsis richteri*, common fire ant, *Solenopsis geminata*, and the southern fire ant, *Solenopsis xyloni*.

Red imported fire ant mound

10-4. HARVESTER ANTS (*POGONOMYRMEX* SPP.)

These are large (5-6 millimeters) red to dark brown ants. They nest only in the soil, but in lawns their nests may be near building foundation walls. Most harvester ants do not make mounds but clear large smooth areas from 12 to 30 feet in diameter. They collect and store seeds of many types of food. These ants are very active and aggressive in protecting their nests and will sting viciously. In the warm dry areas of the southwestern U.S. where they're normally found, these ants destroy vegetation, damage paved areas by extensive tunneling and readily attack people and animals. They have agricultural significance because of their low bare mounds.

10-5. CARPENTER ANTS (*CAMPONOTUS* SPP.)

These are very large dark brown or black ants, measuring 6 to 10 millimeters long. They usually nest in moist wood where they hollow out extensive galleries causing rapid rotting. Consequently, they may damage a variety of products, ranging from wood piles to structural foundations. These ants don't eat wood but feed on honeydew, a secretion they obtain from aphids. Carpenter ants are also predaceous on other insects. They don't sting but will bite readily. There are several widely distributed species in the U.S.

10-6. CORNFIELD ANTS (*LASIUS NIGER AMERICANUS*)

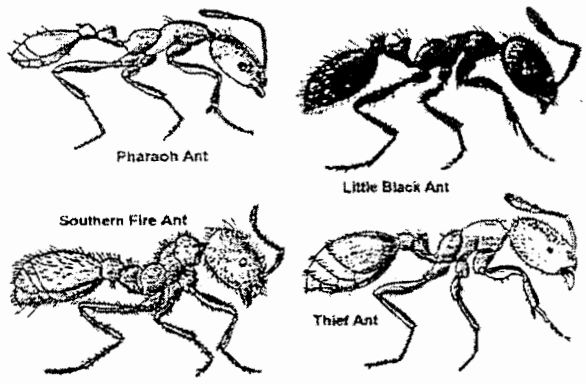
This small (2 to 3 mm) brown ant is widely distributed throughout the U.S. and is probably the most abundant species in this country. It constructs numerous mounds in fields and lawns and will nest around, under and in buildings. Cornfield ants feed mainly on honeydew, but they also tend aphids and are a serious pest in fields where they tend corn root aphids. In buildings, they can be a nuisance when they enter to seek sweet foods, occasionally stinging building occupants.

10-7. THIEF ANTS (*SOLENOPSIS MOLESTA*)

These yellowish ants are among the smallest in the U.S. They're called thief ants because they often nest near the galleries of other ants, raiding them for food. Their own galleries are very small, so they can't be followed by the ants whose nests they raid. They're rarely seen outdoors since they don't normally forage for food above ground. Thief ants feed on a wide variety of plant and animal materials. They can sting but rarely do so. Several subspecies and varieties are generally distributed throughout the U.S. Thief ants readily invade buildings and are among the most important household ants. In buildings, they forage widely for sweet, starchy and proteinaceous foods, but they prefer greasy materials.

10-8. PHARAOH ANTS (*MONOMORIUM PHARAONIS*)

These tiny (1 to 2 mm) ants vary in color from yellow to red. They're distinguished from thief ants by an antennal club that has three segments; the thief ant has only two. Pharaoh ants nest almost anywhere, in cracks and crevices, under stones and boards, and around foundations. They feed on sweets and greases, and are predaceous on many insects. They're distributed throughout the U.S. and are important, persistent pests in buildings where they forage for food. These ants can't sting but will bite.



Some common species

10-9. INTRODUCTION

Section II. ANT MANAGEMENT

There are some ant management techniques pest managers may use in buildings, other techniques are only suitable for use outdoors. Management of some ants requires techniques developed for the particular species rather than measures normally used for other ants.

10-10. INSPECTION

In most infestations, ants soon make their presence known, so special procedures aren't needed to determine the needs and methods of management. This is especially true outdoors. But it is often necessary to make a thorough inspection indoors to find the ants' point of entry into buildings and locate their nests, both outdoors and indoors.

10-11. COLLECTING FOR IDENTIFICATION

Determining effective management measures depends on knowing which species of ants with which you are dealing. As a result, it's often necessary to collect ants and send them to a supporting laboratory for positive identification. There is a variety of simple collection techniques used.

a. Collecting by Jar. It's easy to collect harvester ants and other species by burying wide mouth jars near the nest. Baits are not required but will speed up collection time. Watch the jars; ants can escape by forming a "chain of ants" to escape.

b. Collecting by Brush. Another easy method is to pick up ants by rolling a small brush, such as an artist's watercolor brush, over the backs of foraging ants or ants running on well-defined runs. They typically turn to bite the bristles. Some species will quickly release their grip and fall into the collecting container, while others must be pulled free. Dip the brush in alcohol or other preservative before rolling it over the ants.

c. Collecting by Digging into the Nest. If it is necessary to collect eggs, larvae, pupae, or reproductives, the pest manager will normally have to dig into the nest to expose the ants. Wear protective clothing to excavate large nests, such as those of fire ants. Have the ants identified by a specialist.

10-12. MANAGEMENT OUTDOORS

To manage ants outdoors, such as in an exercise area or around buildings and quarters, pesticides are generally required.

a. Baits. With some species, such as fire ants, only those pesticides that can kill or incapacitate the queen will be effective. This normally calls for an insecticide bait, typically delivered in granular form. Many baits currently on the market contain insect growth regulators as the active ingredient. Most baits are applied in a ring around the mound, consistent with the label. For insecticidal dust, use equipment that blows the dust directly into nests, then blow in clean air to distribute the dust within the galleries.

b. Barrier Treatments. Another dusting technique is to apply dusts as barrier treatments in bands around nest openings. Whether using granules or dusts, leave a clean area between the ring and nest entrance and be prepared to make repeated applications in the

event of wet or windy weather. Mound-building ants often enter and leave nests through tunnels some distance from nests and management may require treatment of areas 10 feet or more in radius.

c. Sprays (mound drenching). Use sprays to saturate mounds after they are opened up. Sprays are effective for area control for species other than fire ants where there are many nests or where nests are hidden but foraging areas are known.

d. Suspensions. Suspensions are the safest sprays to use outdoors. Thoroughly wet down all areas treated. After the water evaporates, worker ants track the residual back into the nest.

10-13. MANAGEMENT INDOORS

Indoors, sanitation carried out by building occupants is an important phase of ant management. It's rare to find heavy infestations of ants in buildings where good sanitation is practiced. Foraging ants can easily find crumbs, grease, food scraps, etc. in open containers and desk drawers. In a short while a number of ants will infest the area.

a. Pesticide Sprays. A number of pesticidal sprays are labeled for ant management indoors. Limit such spraying to spots (per label directions), and to cracks and crevices where ants are most likely to occur. Remember that this method will not kill the queen(s).

b. Dusts. Dusts are usually more effective than sprays indoors, provided they are not unsightly to building occupants. Limit their application to cracks and crevices; workers will carry them back into the colonies, completing the rest of the job. Make sure applications cover cracks and crevices for several feet on each side of entry points. Use equipment that blows dust deep into nest and cracks or crevices.

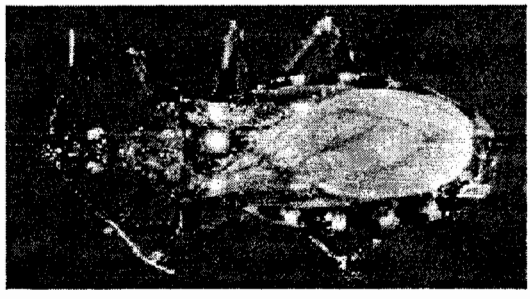
c. Baits. Apply baits to voids and other places where only ants can reach them. Commercial baits are available in tamper proof containers. Baits are often the most effective method of treating ants indoors. Foraging workers carry the bait back to the queen in the nest to an area which is often inaccessible to sprays and dusts.

Section III. TRUE BUGS (ORDER *HEMIPTERA*)

10-14. *HEMIPTERA*

The order *Hemiptera* comprises the true bugs, the only arthropods properly called by that name. Nymphs undergo gradual metamorphosis. Adults generally have two pair of wings; the basal half or more of the forewings is thickened and the remainder is membranous. The hindwings are entirely membranous. Bugs have a scutulum, a triangular body area between the bases of the overlapping forewings. The mouthparts are modified into a beak for piercing and sucking. Bed bugs are annoying pests to humans but transmit no human disease; kissing bugs transmit the trypanosomes causing Chagas' disease in Latin America; but most species of Hemiptera feed on plants.

10-15. CONENOSE BUGS (ASSASSIN BUGS AND KISSING BUGS)



- The family *Reduviidae* has a short, 3-segmented beak attached to the tip of the head, and resting in a prosternal groove when the insect is not feeding.
- Antennae have four segments and the anterior portion of the head is extended.
- There are over 3,000 species of reduviids, about 100 of which suck blood.
- Blood-sucking species are generally abundant in warm areas of the New World from the southern U.S. to South

America. Most other reduviids are predaceous, sucking the blood of other insects giving them the name "assassin bugs."

- One species, *Reduvius personatus*, is known for its painful bite and is commonly called the "masked hunter".

a. Importance.

(1) Disease transmission. Several members of the Reduviid genera including *Triatoma*, *Rhodnius* and *Panstrongylus* are important vectors of Chagas' disease, or American trypanosomiasis. The most important vectors are: *Triatoma infestans*, *Rhodnius prolixus* and *Panstrongylus megistus*.

(2) The attack. Adults of both sexes attack people. Bites of these blood sucking vectors are usually so painless that a sleeping person will not be awakened. They often feed on the cheeks or the angle of the mouth, hence the name "kissing bug."

(3) The transmission. During the blood meal, which may last from a few minutes to half an hour, the insect deposits a small amount of liquid feces on the skin near the feeding puncture. A person may then contract disease organisms by scratching or rubbing infective feces into the bite.

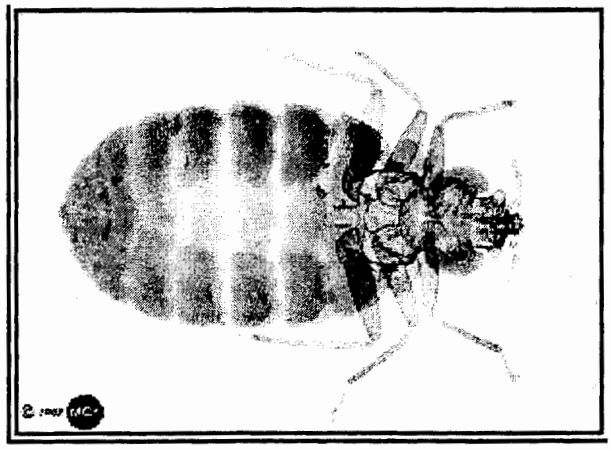
(4) Vector efficiency. Only species that defecate while feeding are effective vectors. Chagas' disease causes anemia, stunted human development and a wasting away of the body; the disease often becomes chronic. Treatment is expensive, and the disease may be fatal.

b. Management.

(1) Habits/location. Conenose bugs that vector Chagas' disease have domestic habits. They hide in cracks in floors and walls and in and under furniture in poorly constructed dwellings. Reservoir animals may live in burrows around and under the same building. Surveys for these vectors are usually limited to a search of cracks and crevices in native or primitive dwellings with a light and forceps.

(2) Surveys/management in endemic areas. In an endemic area, try to conduct such surveys and identify the species found before a building is inhabited. For long-term management, housing conditions should be improved in endemic areas to reduce and exclude reservoir animals and prevent entrance and multiplication of the vectors. When vectors are found during surveys, pest managers should treat sleeping quarters, dwellings and outhouses with insecticides before a structure is occupied.

10-16. BED BUGS



a. Identification. Members of this family are dorsoventrally flattened, wingless insects with a reddish brown color. The body is broad and the prothorax large, bearing flattened lateral projections and indented in the form of a half circle. Wings are represented by thoracic pads that cover most of the metathorax. The head has prominent eyes, two 4-segmented antennae, and a 3-segmented beak. Bed bugs undergo incomplete metamorphosis.

b. Development. The female lays 2-8 eggs per day, which are large and yellowish-white.

- She then uses a secretion to glue eggs to cracks and in crevices under wallpaper.
- She often returns to the same places to continue oviposition, thus causing an accumulation of eggs in one area.
- In warm weather, the eggs hatch in 6 to 10 days; in cooler weather, they may take up to 30 days.

- Young nymphs resemble the adults, except for size. They molt five times before becoming adults.

- Nymphs must have a blood meal between each molt.

c. Importance. Some people are not adversely affected by the bites of bed bugs; in others the irritating salivary secretions cause whitened hard swellings or welts.

- Excessive bites over a period of time may result in nervousness, anemia, insomnia and general malaise.

- Bed bugs have not been incriminated in the natural transmission of any disease, but experimentally, they can transmit a number of disease organisms.

d. Management. People are normally bitten by bed bugs while they sleep, since the bed bug is a nocturnal feeding insect.

(1) Evidence of bed bugs. Evidence of bed bug bites includes blood spots on bed clothing and irritation from salivary secretions. While bed bugs may travel some distance to obtain a blood meal, they are most often found in the immediate area where they feed if there are adequate dark hiding places. Look for them under mattresses, along mattress seams, and around wooden headboards. Bed bugs may also hide behind loose wallpaper and picture frames. Bed bugs may be found in cracks and crevices from floor to ceiling, so conduct surveillance accordingly.

(2) Treating with crack and crevice sprays. To manage bed bugs, use crack and crevice sprays applied to baseboards and other hiding places.

- Cover or remove clothing, rubber material and other objects that need protection from pesticide solvent materials before treating a living area.

- To keep bed bugs from spreading to other areas, DO NOT remove mattresses or other bedding, chests, or furniture items that may be infested.

- Use a two-person team to make these treatments, beginning at one end of a room and working all around.

- Take care to treat all cracks and crevices along floor/wall joints, braces, wall beams and other places capable of harboring bed bugs.

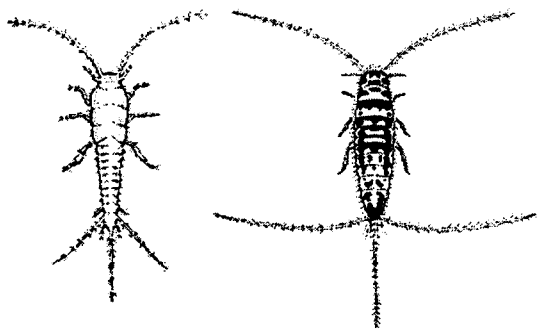
- Treat bed frames and cracks and crevices in quarters or barrack walls up to 4 feet high when only single beds are present and up to 6 feet near double bunks. Use your surveillance results as a guideline for treatment height.

- Treat only the edges and folds of mattresses.

NOTE: It is not necessary treat flat surfaces of mattresses to achieve good management of this pest.

Section IV. MISCELLANEOUS ARTHROPODS

10-17. SILVERFISH AND FIREBRATS (ORDER THYSANURA)



Silverfish and firebrats are among the most primitive of all insects, even pre-dating cockroaches. These long, slender insects have a distinct body form that is broad at the face and tapered gradually to the rear. They are wingless, have long antennae, and several long, tail-like appendages at the abdominal end of the body, giving them the common name "bristletails".

a. Silverfish (*Lepisma saccharina*). The silverfish has a worldwide distribution, although it was probably originally a tropical insect. It has adapted itself to living in temperate climates by dwelling in warm and humid areas, especially in areas such as basements and around water pipes.

(1) Description/preferences. People often bring silverfish into homes in cardboard cartons and on books and papers. Adult silverfish are 1/4 to 1/2 inch long, depending on the species, and are usually silvery in color. They prefer foods high in carbohydrates, such as flour and oatmeal.

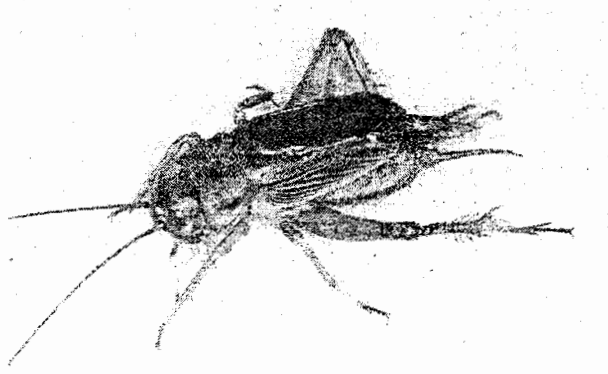
(2) Damage. Most damage, however, is done by their feeding on wallpaper, card files, book bindings, rayon fabrics, starched clothing, and stocks of paper on which paste or glue has been used as a sizing. On military installations, most problems occur in libraries or record storage vaults.

b. Firebrats (*Thermobia domestica*). Firebrats are soft-bodied insects, about one-half inch long, and commonly found around ovens, bakeries, and other extremely warm areas. These active pests prefer dark areas. Paper and paper products, such as books with a glazed finish, are especially susceptible to damage.

c. Management. Silverfish and firebrats can be controlled by applying residual sprays or dusts of approved organic phosphate or carbamate insecticides.

- Give close attention to basements, attics, closets, around bookcases, behind baseboards, and around steam and water pipes.
- Since firebrats prefer hot and dry areas, treat around ovens, fireplaces, boiler rooms, and other hot, dry places.

10-18. FIELD CRICKETS



- These insects are black or black and dark brown, have very long antennae and, like their relatives the grasshoppers, have well-developed hind legs for jumping.
- Crickets (*Tachycines asynamorous*) are best known for their high-pitched chirping sound. However, in some parts of CONUS they're equally known for their invasion of buildings, including living quarters.
- Under ideal conditions, they can build up enormous populations and invade cities and military installations in swarms.
- They feed on almost any organic substance.
  - -- They sometimes do considerable damage to woolens, silk and cotton clothing, as well as other fabrics.
  - -- They normally feed on vegetation of all types and tend to migrate into buildings either when there is great population pressure on limited food sources or more typically when cool fall weather begins.
- Management is normally limited to residual or bait insecticides on building exteriors to prevent entry or to baseboards along walls and in closets after the pests have invaded a building.

10-19. BOXELDER BUGS

These bugs (*Leptocoris trivittatus*) are strikingly marked, red-and-black, sucking insects that frequently are a nuisance during the fall and early warm winter days when they swarm into buildings or congregate in large numbers around trees, on porches, walks, etc..

- They often overwinter in buildings and other dry shelters.
- They're flat-backed, rather narrow bugs, about ½ inch long, black to dark brown colored with three longitudinal red stripes on the thorax and red veins on the wings.
- The nymphs are bright red.
- Management is usually based upon applications of approved insecticidal sprays to affected tree trunks, porches, walks, and caulking.

EXERCISES, LESSON 10

REQUIREMENT. Answer the following questions by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. List the two distinct characteristics that are used to identify ants.

a. _____
_____

b. _____
_____

2. Complete the following statements about the three ant casts -- female, male, Queen.

a. _____ have wings that they retain until death.

b. _____ have wings that they lose after mating.

c. _____ never have wings, except as a rare abnormality.

3. _____ damage crops and attack young pigs, newly born calves, and small animals.

4. _____ destroy vegetation, damage paved areas by extensive tunneling, and attack people and animals.

5. _____ are large dark brown or black (6 to 10 millimeters long). They nest in and hollow out moist wood thus damaging wood products from wood piles to structural foundations.

6. List three ways of collecting ants for identification.

a. _____

b. _____

c. _____

7. To manage fire ants, the Queen must be incapacitated. An effective method is the use of growth regulator. How is growth regulator applied?

_____

_____

_____

8. An important primary method of managing ants indoors is _____.

9. Conenose bugs can transmit _____ disease.

10. List three signs/symptoms of the disease transmitted by kissing bugs.

a. _____

b. _____

c. _____

11. What pesticide formulation is most effective for controlling bed bugs?

_____

_____

12. What types of foods do silverfish and firebrats prefer? _____

_____

LESSON ASSIGNMENT

LESSON 11	Venomous Animals.
LESSON ASSIGNMENT	Paragraphs 11-1 through 11-29
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to react appropriately to venomous animals IAW FM 21-76, *Survival* and AFPMB *Military Pest Management Handbook*.
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the references listed above, you should be able to:

11-1. Identify the characteristics of these insects and apply appropriate measures to control them:

- Honey bees.
- Africanized honey bees.
- Wasps.
- Hornets.
- Caterpillars.
- Moths.
- Spiders.
- Scorpions.
- Centipedes.

11-2. Identify the characteristics of these snakes:

- Nonpoisonous snakes.
- Pit vipers.
- Coral snake.

11-3. Apply appropriate measures to control snakes.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 11

VENOMOUS ANIMALS

Section I. VENOMOUS INSECTS

11-1. INTRODUCTION

Each year, many people are stung, bitten, annoyed, and even endangered by venomous arthropods. Arthropods that may envenomate humans and animals include bees, wasps, spiders, scorpions, ants, caterpillars and centipedes. In recent years in the U.S., venomous arthropods have caused about twice as many human deaths as snakebites. Most deaths from

wasp and bee stings are to people who are sensitive to particular venoms. When arthropod venoms enter the body, they act in one or more of the following ways:

- They act directly on the blood cells (hemolytic).
- They act directly on the nervous system (neurotoxic).
- They may produce an infiltration and congestion of blood (hemorrhagic).
- They may affect the immune system to produce an allergic reaction including potentially fatal anaphylactic shock.

11-2. EFFECTS OF ARTHROPOD VENOM

Arthropod venoms enter a person's or animal's body: by bite, by sting, or by contact. Its effects may be localized and no more important than the production of a sensitive or painful area, or it may be systemic and possibly fatal. Secondary infections may also accompany arthropod bites and stings.

Section II. VENOMOUS INSECTS- THE HONEY BEE

11-3. GENERAL INFORMATION

Stinging hymenoptera include the ants, bees, wasps and hornets. Females of these insects usually have a specialized ovipositor known as a sting, which is more or less adapted for piercing skin of higher animals or other insects. They use the sting either as an organ of defense or offense. In the latter case, it is often used to procure food for the offspring.

11-4. HONEY BEE BIOLOGY

Bees are in the superfamily *Apoidea*, and are readily distinguished from wasps by the presence of plumose (feathery or branched) hairs, especially on the thorax.

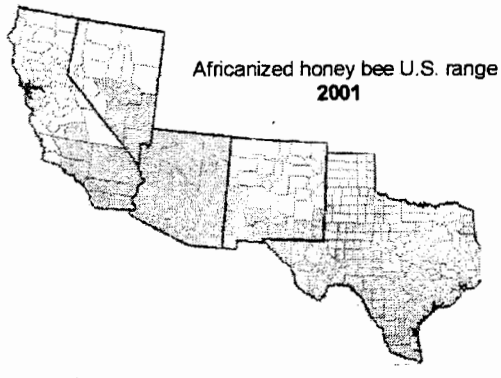
a. Solitary Bees. Many bees live a solitary or sub-social existence. Each female develops her nest, lays eggs, and stores provisions for her brood without the aid of a worker caste.

b. Social Bees. Others, such as bumblebees (*Bombus* spp.) and honeybees (*Apis mellifera*) are social bees, having a worker caste in their colonies.

- Bumblebees form temporary colonies with only the fertilized young queen surviving the winter.
  - -- In the spring, the queen nests in the ground (or deserted rodent burrow) and forms a new colony.
  - -- Workers sting when defending the colony.
- Honeybees build permanent colonies that may survive indefinitely.
  - -- Worker honeybees will readily sting an invader in defense of the colony.
  - -- Periodically a swarm of workers will split from the main colony to start a new one.

11-5. THE AFRICANIZED HONEY BEE

The Africanized honeybee, a subspecies of the honeybee, was introduced into Texas by way of Mexico in 1990. It is continuing to spread through the southern tier of states. The northward limit will depend upon its ability to adopt overwintering behavior, which it currently does not exhibit.



a. Morphology. Morphologically, the two subspecies are inseparable. However, the Africanized honey bee swarms much more frequently than the European bee (seven to eight times compared to one to two times per year) and, unlike the European bee, exhibits mass stinging behavior very rapidly when disturbed around the hive. The stinging behavior has given the Africanized bee its nickname, the "killer bee."

b. The Sting. Although it is true that the hundreds of bee stings that may result within minutes after arousal of the hive can kill a person or animal under some circumstances, the venom of the Africanized bee is no more potent or voluminous than the European bee.

- People who are properly educated about what to do in case of attack should have little cause for fear.
- The most important action is to escape the attacking bees as quickly as possible.
- Once the attack has begun, it is imperative to get in a closed vehicle or building, or take cover under protective garments as soon as possible.
- Once the stinging stops, the risk is over except for allergic persons, who should use an antivenom kit just as they would for ordinary European bee stings.

11-6. MANAGEMENT

Management techniques depend on the species of bee requiring control.

a. Honey Bees. It is preferable to move honeybee colonies rather than destroy them. It is best to have an experienced beekeeper transfer the colony to an empty hive, especially in areas invaded by Africanized bees.

- This salvages their beneficial contribution as honey producers and plant pollinators; many beekeepers perform this service without charge.

b. Other Bee Species. With other bee species or when honeybees cannot be saved, chemical treatments should be used as a last resort.

- Make pesticide applications at night or on overcast days when bees are less active.
- Indoors, use a synthetic pyrethrum aerosol.
- Make sure to remove the nest to prevent other bees from reoccupying it after the pesticide residual wears off. Also, the comb, larvae and honey may attract stored products pests if not removed.

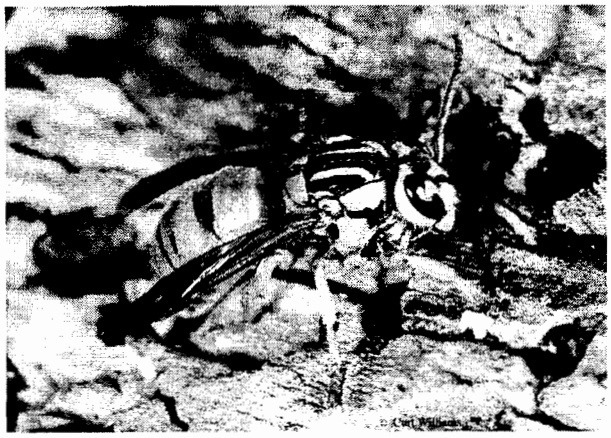
Section III. VENOMOUS INSECTS - WASPS AND HORNETS

11-7. BIOLOGY

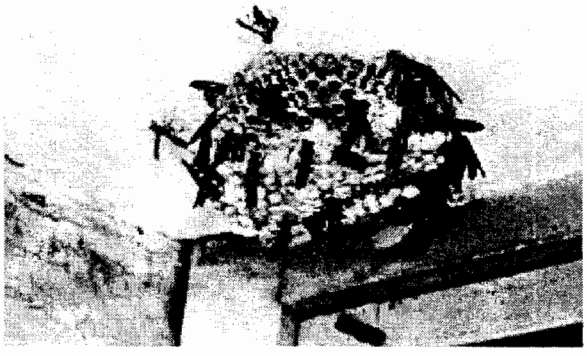
More than 4000 species of wasps occur in North America. About 50 species are troublesome to people. These can be divided into the following groups: (1) hornets and yellow jackets (*Vespa* and *Vespula* spp.); (2) paper wasps (*Polistes* spp.); and (3) mud daubers (*Sceliphron*, *Chalybion* and *Trypoxylon* spp.).

a. Identification. Wasps are distinguished from one another by their body structure and the nests they build.

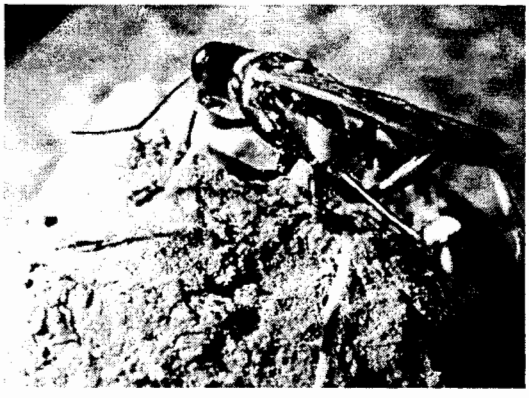
- Hornets and yellow jackets. Hornets and yellow jackets are stockier than paper wasps and mud daubers. They are black, with yellow or white markings.



- Paper wasps. The paper wasps are long, slender wasps, about 3/4 inch long, black, brown or red with a few yellow markings.



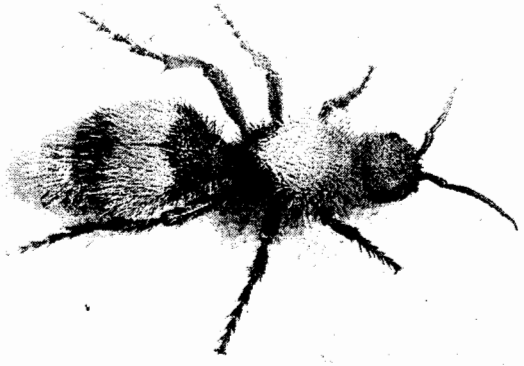
- Mud daubers. Mud daubers are also slender, about 3/4 inch long, and are black and yellow (*Sceliphron*), metallic blue (*Chalybion*), or shiny black (Tr*ypoxylon*).



b. Nests.

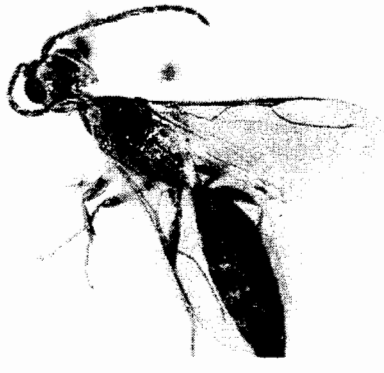
- Hornet and yellow jacket nests are globular, paper-mache structures concealing multi-cell combs. They are usually above ground but some species nest underground.
- Paper wasp nests are single-layered, open faced and umbrella-shaped.
- Mud dauber nests consist of several clay cells. After placing one egg and several paralyzed small spiders in each cell, the female caps the cells and leaves the nest.
- Size of the wasp's nest. The size of the wasp's nest depends on the number of wasps living in them and they are enlarged to accommodate the growing population.

c. Family *Multillidae*. Among the lesser known stinging Hymenoptera are wasps in the family Mutilldae, commonly called velvet ants, wool ants, and cow or horse killers.



- Most mutillids are covered with a velvety pubescence and are brightly colored with orange, red or yellow.
- Females are wingless, good runners and inflict painful stings.
- These wasps are parasites of bees and other wasps.

d. Bethylid Wasps. Bethylid wasps (superfamily Bethyloidea) are parasites of hymenopterous, lepidopterous and coleopterous larvae. Three genera, *Cephalonomia*, *Scleroderma* and *Epyris*, will sting people. These small insects may become abundant in houses as a result of a persistent infestation by one of their hosts.



11-8. MANAGEMENT

a. Sanitation. As with many pests, one of the most effective ways to manage wasps is by applying good basic sanitation. Wasps around food preparation or storage areas are usually indicative of lax sanitation standards. Rapid garbage disposal alone will reduce wasp numbers around garbage.

- Pesticides. Pesticides recommended for controlling bees are usually also approved for wasp control. Focus pesticide applications against nests and surrounding areas in the early morning or late evening when most wasps are in the nest and are least active.

- Dusts. It's easy to apply dusts to some hornet and yellow jacket nests whether they are above or below the ground. Insert the extension tube on a hand duster into the nest opening. Two or three strong puffs of dust will filter through the nest and will usually kill the colony in 24 hours.

- Sprays. Spray solutions and emulsions into and onto the nest from a distance for maximum personal protection.

b. Detergent. A small amount of dish detergent in water is an effective alternative to pesticides. A mixture of about 16 ounces of detergent in 2 1/2 gallons of water provides very fast knockdown and is virtually non-toxic.

Section IV. VENOMOUS INSECTS - CATERPILLARS AND MOTHS

11-9. BIOLOGY

a. Identification. Caterpillars are larvae of moths and butterflies and are in the order Lepidoptera. In the U.S., there are ten families with species troublesome to people. Many more irritating species are found around the world.

- Larvae of some moths and butterflies have large spines that, while harmless, create the false impression that they are dangerous.

- On the other hand, most of the caterpillars with urticating (stinging) or nettling hairs appear harmless. Some are actually attractive and strikingly colored.

b. Venomous Caterpillars. While the medical importance of the order Lepidoptera is mainly due to urticating hairs, some caterpillars, such as larvae of the cabbage butterfly (*Artogeia rapae*), have poisonous body fluids which produce intestinal inflammation and death in cattle that ingest them with food.

- Caterpillars produce venom in glands at the base of hairs.

- Poison glands are sometimes outside the body surface, and these may occur singly or in clusters.

- When a victim contacts the hairs associated with venom glands, the venom may emerge through an opening at the tip of the spine or the spine may break off in the wound, and release the venom.

11-10. PUSS CATERPILLAR (*MEGALOPYGE OPERCULARIS*)

a. Identification. This caterpillar is about an inch long when fully grown. It has a thick, fleshy body completely covered and hidden by long, silken hairs of a tawny to grayish color. Under the long hairs are numerous short spines in rows on tuberculate ridges and connected with underlying poison glands.

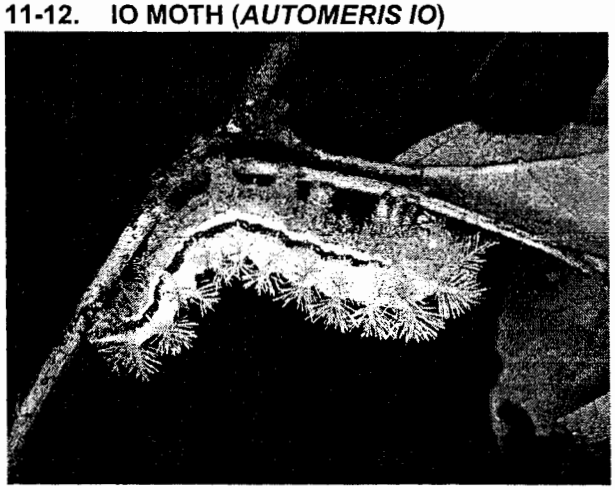
b. Distribution/Problem. This species is quite common in the southern U.S., and at times becomes very abundant.

- Schools have been closed in some areas until these caterpillars were brought under control.
- The severity of symptoms depends largely upon individual reactions.
  - -- The initial reaction is usually an intense, burning pain immediately after contact.
  - -- This is followed by raised papules and reddening, then by generalized swelling and numbness, which may be followed by nausea and vomiting.

11-11. FLANNEL MOTH (*NORAPE CRETATA*)

This caterpillar is similar to the puss caterpillar and replaces it in the northern states. The related *Logoa pyxidifera* is found in Georgia and neighboring Atlantic states. These two caterpillars, like the puss caterpillar, attack shade trees and their stings can be extremely painful.

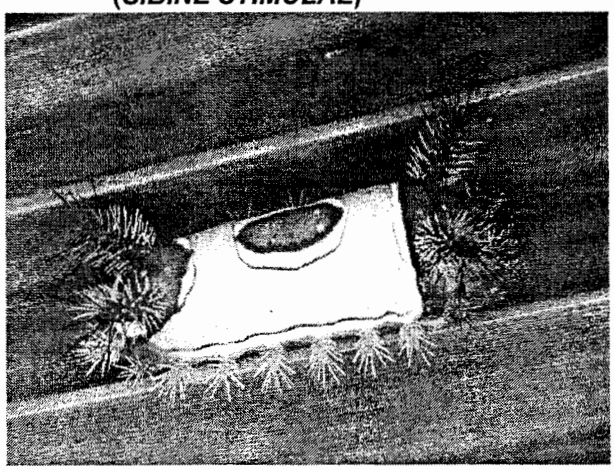
11-12. IO MOTH (*AUTOMERIS IO*)



a. Identification. This caterpillar is common throughout the eastern and central U.S. and is probably the most familiar nettling caterpillars. It feeds on several food plants, including willow and even corn. Full grown larvae are about 2 ½ inches long. It is pale green with sublateral stripes of red and cream. Many green spines, with a few black ones among them, radiate from tubercles on the body creating a mossy appearance.

b. Poison. Some of the long spines have hairs but the poison spines have peg-like tips and are connected with very large venom glands. Direct contact with the larva and its nettling spines normally causes intense itching.

11-13. SADDLEBACK CATERPILLAR (*SIBINE STIMULAE*)



a. Identification. The saddleback caterpillar is found throughout the central, eastern and southern states where it feeds on several types of forest and fruit trees.

- It is not usually numerous in any location.
- However, because of its color and interesting pattern, people often try to pick it up with bare hands and are stung.
- This caterpillar has a purplish brown spot surrounded by a large green patch; together they look like a dark saddle on a green blanket.

b. Poison. It has tufts of bristling stout spines with acutely pointed tips. The spines are connected with poison glands. The poison affects some people severely, causing extreme pain.

11-14. MANAGEMENT

To manage stinging caterpillars effectively, use one of several carbamate pesticides labeled for such use.

- Spray a suspension on the foliage and branches so infested areas are thoroughly wet. When using chemical measures against caterpillars which easily shed their nettling spines, try to obtain a complete kill in the shortest time possible.

- Slowly dying caterpillars move in a convulsive manner and will shed many hairs and spines before dying.

Section V. VENOMOUS ARTHROPODS - SPIDERS (ORDER *ARANEIDA*)

11-15. BIOLOGY

a. Identification. Spiders are cosmopolitan in distribution, but most are found in temperate and tropical zones. Spiders use their venom to paralyze their prey or in defense. People are not usually bothered by spider venom. Few spiders have mouthparts that can penetrate human skin and most of those have venom that produces only local symptoms or an occasional allergic reaction. There are, however, dangerously venomous spiders in many parts of the world, and they may be locally abundant.

b. Description. Spiders have eight legs, no wings and no antennae.

- Unlike scorpions, ticks and mites, spiders have an unsegmented abdomen attached to the cephalothorax by a short pedicel or stalk.

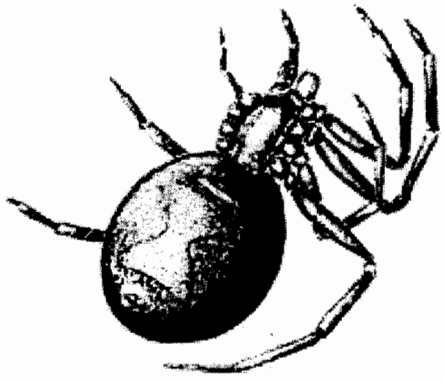
- The eyes are simple, usually eight in number, grouped together or separated across the head.

- The head also has a pair of leg-like pedipalps and a pair of chelicerae with fangs.

- There are many types of spiders showing considerable variation in size, color, web-spinning characteristics, hunting techniques, and other distinctive characteristics.

- After hatching from eggs, immature spiders pass through several stages before they reach sexual maturity.

11-16. BLACK WIDOW (*LATRODECTUS MACTANS*)



a. Identification. Female black widows are 12 to 14 mm long; males are about half that size. Almost the entire body is usually bright shiny black, but in some specimens, the thorax and legs may be dark brown. On the underside of its abdomen, the female has an hourglass-shaped marking that is usually bright red. In addition, males have rows of red spots, diagonal yellowish stripes, or various straw colored markings on top of the abdomen.

b. Life Cycle. Females attach several egg sacs, each having an average of 200 eggs, to her web. In 2-4 weeks, the eggs hatch into tiny whitish-gray, active young spiders that are cannibalistic. Eggs are usually laid during the summer and the young reach maturity the following spring.

c. Habitat. These spiders are commonly found under privy seats, in piles of lumber and trash, and in empty paint cans and buckets. They may be common beneath houses in some areas, and may infest storerooms and garages. Webs of this spider are extremely irregular and loosely woven, and the tube where the female rests is not in plain view. Black widows live in dark areas and generally avoid light.

d. The Poison. Their normal food is insects, and they usually bite people only if physically disturbed.

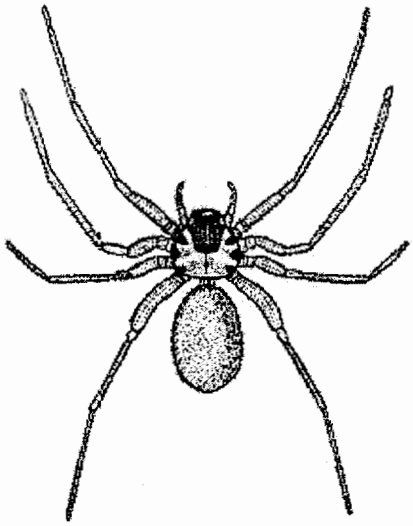
- The female's bite, although not as venomous as generally believed, can cause death, the death rate being about five percent in untreated cases.

- The venom acts as a neurotoxin causing muscle spasms and continuous muscle contraction, especially in the abdominal muscles. Nausea and profuse sweating often occur. Fatalities are usually the result of asphyxia due to respiratory arrest.

- Most deaths in the U.S. are among migrant workers in California vegetable fields.

- The male black widow produces little venom and the mouthparts are not sufficiently strong to penetrate human skin.

11-17. BROWN RECLUSE SPIDER (*LOXOSCELES RECLUSA*)



This spider has been responsible for a number of cases of necrotic spider poisoning in central and southwestern U.S. It is common in Arkansas, Missouri, Louisiana, Oklahoma, Texas, and some parts of California.

- It is easy to identify this spider by the fiddle-shaped marking found on the dorsum of the cephalothorax.

- This species is found in bathrooms, bedrooms, closets, basements, smokehouses, etc.

- In areas where it is common, it has been found in folds of seldom-used clothing hanging in closets or other storage spaces.

- Unlike the bite of the black widow, that of *Loxosceles reclusa* is localized, but it produces considerable local necrosis or tissue damage that may ultimately produce an unsightly scar.

- Consult with a physician if you are bitten by a brown recluse spider.

11-18. MANAGEMENT OF SPIDERS

Management measures for spiders include individual awareness, physical measures and pesticide applications.

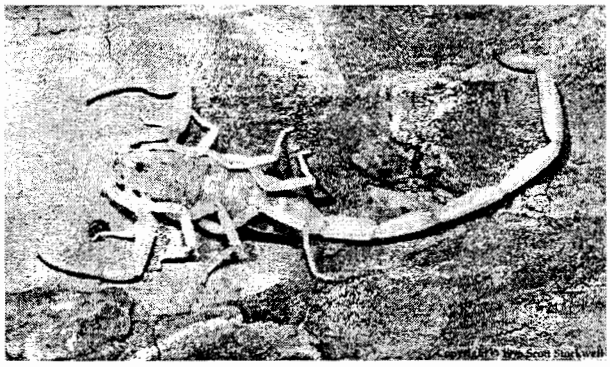
a. Educate the Populace. As with other pests, people should be taught where poisonous spiders are found and to use caution when placing bare hands into such areas or sleeping on the ground.

b. Physical Methods. Physical methods, such as cleaning up all possible breeding areas, are of considerable value in managing spiders. Take care to destroy webs in buildings and inhabited areas and to kill the spiders by crushing or with insecticides. Always destroy black widow egg sacs, since up to 300 young spiders may emerge from each one.

c. Preventive Measures. For the brown recluse, good sanitation, ventilation and lighting does much to prevent this spider from finding harborage.

d. Military Installations. On military installations, spiders are most often a problem in inactive storage areas and quarters. Insecticide dusts and sprays are effective against spiders, and even aerosols will make them drop from their webs so they can be easily crushed. Residual applications are less effective then contact sprays.

Section VI. VENOMOUS ARTHROPODS - SCORPIONS



11-19. BIOLOGY

Scorpions belong to the order Scorpionida in the class Arachnida. There are six families with over 650 species distributed throughout the tropics, subtropics, and warm temperature parts of the world. Many scorpions invade dwellings to find food or shelter, and others are found in areas people use. While most scorpions can cause only painful stings, some species can cause death.

a. Description. Scorpions have four pairs of legs and one pair of large claws (pedipalps).

- The body has two divisions: the anterior unsegmented cephalothorax, and the posterior, segmented abdomen.
- The last six abdominal segments form the "tail" with the end segment modified to form a hooked stinger.
  - -- The end segment, or telson, has two poison glands.
  - -- The tail is arched over the back, and it inserts the stinger into its victim by a quick forward thrust; venom is injected through the needle-sharp hollow stinger.
- Adult scorpions vary in length from less than an inch to almost eight inches.
- Colors vary from nearly black to straw color, and some scorpions are striped.
- Most have smooth bodies, though some are hairy.
- Scorpions bear live young.
- Scorpions are nocturnal and seldom seen during the day unless they are disturbed in their hiding places.

b. Medical Importance. Medical importance of scorpions is determined by their habits and venom potency, not by their size.

- Some of the most dangerous species seldom exceed three inches in length.
- Most medically important scorpions are in the genus *Centruroides* found in portions of the southwest U.S. and Mexico.

c. Location of Other Scorpions. The genus *Tityus* is found in central and south America. The genera *Buthus* and *Androtonus* are found in southern Europe, the Middle East and north Africa, and genus *Perabuthus* is found in South Africa

11-20. MANAGEMENT OF SCORPIONS

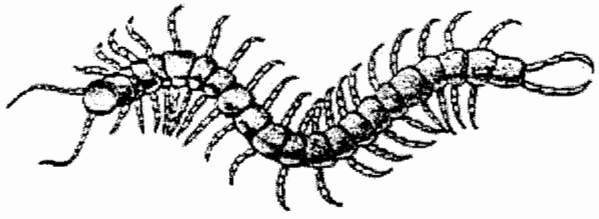
a. Avoidance. Avoidance is the best method for preventing stings and should include picking up objects carefully to prevent contact with scorpions hiding underneath. Empty shoes and slippers vigorously before putting them on, do not walk around barefooted after dark, and shake out clothing. Do not dump clothing on the floor but carefully hang it, preferably away from the wall. Keep beds in heavily infested areas away from walls; in some cases it may be necessary to place bed legs in clean wide-mouthed glass jars.

b. Trapping Scorpions. To trap scorpions in heavily infested areas, use wet burlap sacks or other pieces of course cloth spread on the ground in the evening.

- Scorpions will crawl under the sack during the night and are easily destroyed the next morning.

- Cleaning up trash piles will reducing their habitat.
- Insects are the principal food for scorpions; therefore, eliminating food sources reduces the area's attractiveness to scorpions.
- Many species take three to five years to reach maturity. Seeking out and destroying these animals on a regular basis will cut down on their numbers enormously.
- Residual sprays or dusts applied to harborage areas give good control of scorpions.

Section VII. VENOMOUS ARTHROPODS - CENTIPEDES



11-21. BIOLOGY

Centipedes belong to the class Chilopoda. These animals are found in tropical, subtropical, and warm temperate parts of the world.

a. Identification. They are all predacious, with well-developed poison glands used to kill their prey.

- These glands are at the base of the first pair of legs, which arch forward to function with the mouthparts.
- These legs end in pointed claws, which have outlets for the poison glands used to kill their prey.
- The body has a distinct head and 15 to 170 or more similar body segments.
  - -- Each segment has one pair of tracheal openings and one pair of 7 jointed legs.
  - -- The head has a pair of extremely long multi-jointed antennae, a pair of strong mandibles and two pairs of maxillae.
- Members of some species may measure ten inches or more, but the usual size is one to two inches.
- Adults of several species have shinning, greenish or blackish bodies and orange or red legs and heads. Some are yellowish with dull red longitudinal bands, and still others are markedly phosphorescent.
- Sexes of centipedes are distinct and the females either lay eggs or give birth to live young.
- The young resemble adults, having approximately the same number of segments.
- Millipedes (class Diplopoda) are often confused with centipedes, but differ by having two pairs of legs per body segment, and a nearly rounded rather than flattened body.

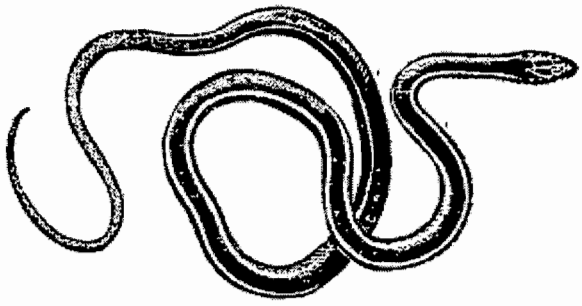
b. Activity. Centipedes are nocturnal. They hide by day under stones, rubbish, leaves, logs, and in other dark places. They feed by night on earthworms, insects, etc. The common long-legged house centipede, *Scutigera forceps*, is usually regarded as quite beneficial because it feeds on household insects.

c. Relations with People. Most centipedes are harmless to people since few species have fangs strong enough to penetrate human skin. They bite only when molested or threatened. The secretion they inject is primarily a digestive enzyme, containing only a small portion of venom.

11-22. MANAGEMENT OF CENTIPEDES

Properly screening houses usually keep centipedes out. Also, doors should fit tightly. Caution when disposing of centipedes is about the only other preventive measure for avoiding bites.

Section VIII. VENOMOUS AND NONVENOMOUS SNAKES



11-23. INTRODUCTION

Few animals are more disliked or misunderstood than snakes. Most snakes aren't poisonous, and many are beneficial because of the number of rodents and insects they eat. Although poisonous snakes have no place in a settled community, nonvenomous snakes should be given as much consideration as any other animal that directly or indirectly assists in combating pests.

11-24. DESCRIPTION AND BIOLOGY

Snakes are called "cold-blooded" animals because their body temperature varies with that of their surroundings. In reptiles, body temperature is maintained by moving to and from warm places and not by internal controls as in birds and mammals.

a. Snakes and the Environment. Most snakes perish in intense heat or sub-zero temperatures. In temperate climates, all snakes hibernate. Their survival depends on evading frost, and they will crawl into stumps, holes in the ground, or rock crevices where frost doesn't penetrate. At times, large numbers congregate in a single cavity to pass the winter.

b. Life Cycle. Some snakes lay eggs, while others give birth to living young which hatch from eggs retained within the female's body.

- Brood size and number of eggs varies among species and even individuals of the same species.
- The young of poisonous snakes have fangs and poison glands at birth.
- Snakes store food in the form of fat in the body cavity.
- Being cold blooded, they're relatively sluggish and use this food reserve slowly.
- In temperate climates, well-fed snakes can hibernate all winter without feeding.
- Large snakes have lived three to four years without eating.
- Snakes do require water, which they drink by submerging their mouths and sucking.

c. Snake Behavior. Except for a few species in Southeast Asia and Africa, snakes are generally passive by nature and will avoid contact with people unless cornered or injured in some way. Nonpoisonous snakes are often more prone to attack than are poisonous ones.

d. Snake Senses. Snakes don't have external ears and are deaf, but they are extremely sensitive to vibrations and very small differences in temperature. Ground dwelling, nocturnal species don't see very well and can't see at all when they're shedding. All snakes are predatory and swallow their prey whole.

e. Snakes in Water. Stepping on a snake under water is just as dangerous as on land because a snake may strike while swimming, although its effectiveness in striking is reduced. All snakes can swim and some species can stay under water for hours.

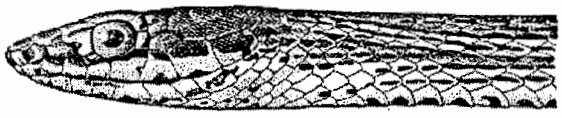
11-25. NONPOISONOUS SNAKES

As a rule, nonpoisonous snakes should be protected for the benefits they provide as rodent control. However, they're usually killed because they're assumed to be poisonous. Therefore, it's important to know the differences

between poisonous and harmless species and to release nonpoisonous snakes away from quarters, offices and training areas.

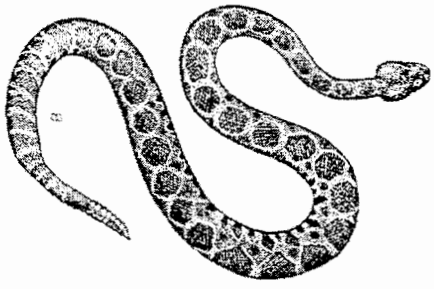
- Except for coral snakes, nonpoisonous snakes in the U.S. have non-triangular-shaped heads and their teeth are almost uniform in size.

- The eye pupil of most nonpoisonous species is round, and there is no pit or opening near the nostril.

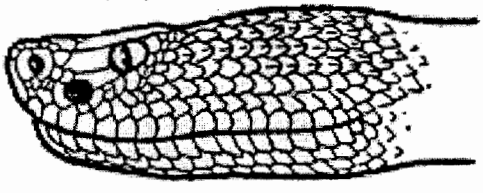


- Scales on the underside of the tail are divided.

11-26. POISONOUS SNAKES



In the Continental United States (CONUS), most poisonous snakes are pit vipers in the family Viperidae. The name pit viper comes from the fact that these snakes have an opening or "pit" on either side of the head between the eye and the nostril. These loreal pits are heat-sensitive openings the snake uses to locate warm-blooded prey.



a. Description. The head of pit vipers has a triangular shape and the eye pupils are elliptical. Pit vipers have a pair of large, movable fangs on the upper jaw. Each fang is connected by a tube to a poison gland located behind the eye. The scales on the underside of these snakes' tails are undivided. Pit vipers include numerous species of rattlesnakes, the water moccasin or cottonmouth and the copperhead.

b. The Coral Snake. The only other poisonous snake in the U.S. is the coral snake. Coral snakes belong to the family Elapidae and differ from pit vipers in that they have round pupils and don't have a triangular head or movable fangs.

- They're most readily identified by their bright and distinctive color pattern of red, yellow, and black bands with red and yellow bands always touching.

- The milk snake has the same colors, but the red and yellow bands don't touch.

- Coral snakes are relatives of the Asian cobra and are highly poisonous.

c. Coral Snake Bite. Because the coral snake is rather small (seldom over 1 to 2 feet long) and has immovable fangs, it's seldom a problem unless handled or in a position where it can bite a person on a small appendage, such as the fingers or on the ear lobe. With fixed fangs, the coral snake must chew on fatty tissue to inject its venom.

11-27. FOREIGN SPECIES

Most of the world's deadliest snakes are found in countries other than the United States.

- Pest managers. Pest managers should know about snakes like the cobras, vipers, and sea snakes in their area. These snakes can cause death or serious injury.

11-28. FIRST AID

The only first aid non-medical people should administer is to immobilize the limb where the bite has occurred and transport the victim to the nearest medical facility.

- If it takes more than 30 minutes to get to a medical facility, place ice-filled towels around the bite site and constricting bands 2 finger widths above and below the bite site.

- These bands should be just tight enough to stop superficial venous and lymphatic circulation, but not interfere with arterial circulation.

- Commercial cold packs may slow the movement of venom. However, care should be taken to prevent freezing of tissue that may be more dangerous than the bite.

CAUTION

NEVER place ice in direct contact with skin.

NEVER add salt to ice to cause it to melt.

11-29. MANAGEMENT OF SNAKES

The first step in snake management is to find out what kind of snake is creating the problem and learn about its habitats. Management measures discussed below are very general and include repellents as well as miscellaneous methods. One or more of these methods may be applicable in any set of circumstances.

a. Snake Proofing. Snakes occasionally enter buildings either by accident or in search of food or shelter.

- Snakes can be excluded by sealing all openings around the foundation.

- Cellar doors, screens and windows must fit tightly.

- Galvanized screen of 1/4 inch mesh or smaller should be fastened over drains and ventilators leading to the outside.

- Fences around buildings also help keep snakes away from yards and other areas; it's fairly expensive but may be justified if the yard is used as a play ground for children.

b. Remove Food and Cover. Snakes can be discouraged from an area if food and cover are removed.

- Managing rodents and other food species decreases the available food supply and helps lower snake populations.

- Removing snake harborages (rock piles, woodpiles, tall grass, weeds, and brush) also gives snakes fewer opportunities to become established. Remember that even a drastic reduction of the rodent population in an area will not bring about an immediate reduction of the snakes because of their ability to go for long periods of time without food.

- In addition, any remaining rodents, due to their reproductive potential, will soon build up in numbers sufficient to keep a snake population in existence.

- Because of this, rodent management must be a continuous program.

c. Searching and Killing. This management method is the most obvious and sometimes the most practical way to manage snakes.

- Searching and killing can reduce snake numbers in a given area, but this program must be persistent since not all snakes are active at the same time.

- In areas where snake dens are common, it's often possible to kill large numbers of them in the spring when they first emerge in a sluggish condition to lie in the sun.

- Sometimes snakes can't be found because they hide very effectively in buildings.

- One way to find a snake is to place damp cloths at various locations where snakes may be, and then cover the damp cloths with dry ones.

  -- When snakes find this type of moist shelter, they often crawl under it.

EXERCISES, LESSON 11

REQUIREMENT. Answer the following questions by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. List three ways that arthropod venom enters a person or an animal's body.

   a. _____

   b. _____

   c. _____

2. Honeybees are beneficial to mankind as:

   a. _____

   b. _____

3. How and what year did the Africanized honeybee enter the U.S.?

   _____

   _____

4. What causes Africanized honeybees to engage in mass stinging? _____

   _____

5. The brown recluse spider can be identified easily by the _____ found on the dorsum of the cephalothorax.

6. The best method to manage scorpions is

   _____.

7. Why are snakes called "cold blooded?"

   _____

   _____

   _____

8. In pit vipers, the shape of the head is _____ and the shape of the pupils are _____.

9. The best way to identify the coral snake is

   _____

   _____

   _____

10. A snake has bitten a person on the leg. First aid given by a non-medical person is to

    _____

    _____

    _____

    _____

LESSON ASSIGNMENT

LESSON 12	Bird and Bat Management.
LESSON ASSIGNMENT	Paragraphs 12-1 through 12-15.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to employ integrated pest management principles to control birds and bats IAW AFMPB *Military Pest Management Handbook*, FWS Resource Pub 143, *House Bat Management*, and TG 142, *Managing Health Hazards Associated with Bird and Bat Excrement.*
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the references listed above, you should be able to:

12-1. Identify the following bird species that often require management.

- Geese
- Pigeons (Rock doves).
- English sparrows.
- Starlings.
- Gulls.
- Woodpeckers.
- Swallows.
- Grackles.

12-2. Describe the three main management techniques for temporary control of birds.

12-3. Identify trap placement recommendations for pigeons, English sparrows, and starlings.

12-4. Identify the reasons for conducting bat management.

12-5. Describe the three main bat control techniques.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 12

BIRD AND BAT MANAGEMENT

Section I. BIRDS

12-1. INTRODUCTION

a. Positive Effects of Birds. Both wild and domestic, birds provide recreation and food for people. They eat insect pests of crops, lawns and trees and often feed on weed seeds, thus preventing the growth of pest vegetation. As scavengers and carrion feeders, they remove both natural and human-made refuse. They also prey on snakes and rodents, helping to control these pests.

b. Negative Aspects of Birds. As human activities have expanded over the years, people have routinely displaced birds from their habitats and, in doing so, we've discovered that under some circumstances birds are detrimental to our well being. For example, birds can be reservoirs of diseases and arthropod pests that attack people.

12-2. IMPORTANCE

Many of our relations with birds are based upon their beauty and flight abilities, but on the negative side birds may contaminate our food and damage dwellings and equipment.

a. Birds and Damage. Though birds may save trees or plants from injuries caused by arthropod pests, they can also damage vegetation through their roosting and nesting habits. When bird flocks inhabit structures, they become a noise nuisance, cause fecal contamination of walkways, roads, or vehicles, and become a source of disease for person living and working around them. They're also hosts to ectoparasites such as fleas, mites, ticks, and bugs which bite people. Parasites and many other pests common to bird nests routinely enter buildings and annoy people.

b. Birds vs. People. Although human flight was inspired by birds, birds and people often come into conflict in the air. On military installations birds are chiefly a problem around airstrips, where flocks may interrupt, damage and even destroy aircraft, injuring or killing pilots and passengers. By the time World War II started, bird hazards to aircraft were well documented. With the advent of jets, the potential for engine failure and fatal crashes increased sharply, since birds are easily sucked into engines where birds cause turbine damage. Also, the higher speed of jets increases the risk of windscreen damage. In 2001 alone, wildlife strikes (primarily birds) caused nearly $32,000,000 worth of damage to USAF aircraft. Although the most recent human fatality attributed to bird airstrikes occurred in 1999, the risk of human fatality is certainly still present.

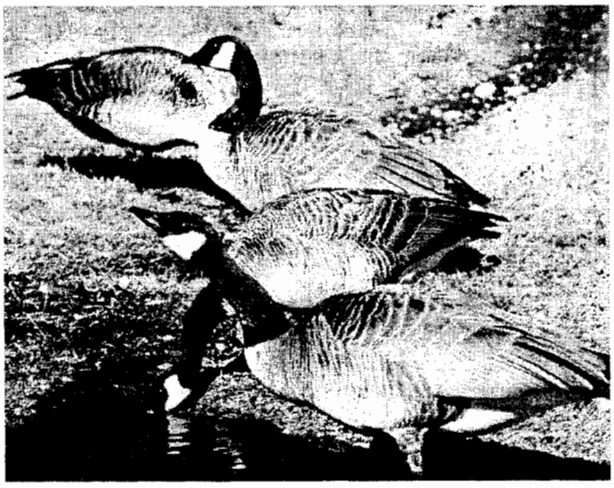
c. Birds and Safety. Likewise, in aircraft hangers and maintenance areas, bird droppings quickly corrode engine parts, electronic equipment, and air frame surfaces. Semiannual bird migrations also affect flying safety. Local roosts may be periodically occupied or vacated throughout the breeding season.

d. Birds and Cold Weather. As cold weather approaches, many species migrate south. Others, such as pigeons, move into sheltered areas around buildings. The birds most often encountered as pests on military installations in the U.S. are pigeons (Rock doves), grackles, starlings, cowbirds, English sparrows and various species of gulls. Because of laws that protect some species you should always consult with the environmental office before enacting a control program. Most birds are protected by the Migratory Bird Treaty Act, however Rock doves, starlings, and English sparrows are introduced species not protected by this law.

12-3. DESCRIPTION, BIOLOGY AND HABITATS

Managing pest bird populations is a frequent problem at military installations and is one of the most difficult management actions pest managers may have to perform. The following species often require management.

12-4. CANADA GOOSE (*BRANTA CANADENSIS*)



Canada geese (as well as other species of geese) are often nuisances on DOD property, as well as being extremely hazardous to aircraft. This is such a serious problem that the USAF uses radar and thermal imagery to detect the presence of flying geese. Geese also cause problems in parks and around golf courses, where they defecate on paths and near ponds or lakes. They may be aggressive beggars in some situations.

a. Biology. The Canada goose population is increasing rapidly, and many birds no longer migrate, making them a year-round problem. Canada geese are herbivores that prefer short, cultivated grasses such as those found around airfields, golf courses, and parks.

b. Management. In 2001, a Federal judge ruled that Canada geese (as well as all other migratory birds) on DOD installations could not be "taken" without a permit. This means that pest managers may not kill, relocate, or even disrupt the breeding of geese without a permit. You should always check with the US Fish and Wildlife Service or the appropriate service personnel prior to conducting any goose management. Some goose management options include the following.

- Canada geese may be captured and relocated in some instances. However, they often return to the original site.
- Lethal adult control may by authorized under some circumstances.
- Egg replacement involves removing viable eggs and replacing them with a fake or nonviable egg. The geese will continue to incubate these replacement eggs. If eggs are simply removed with no replacement, the geese will rebreed.
- Vigorous egg shaking or addling will kill the developing embryo.
- Some chemical repellents are available.
- Pest controllers may employ Border collies or other methods of scaring birds away. Even scaring birds may require a permit if it causes adults to leave the nest or otherwise disrupts breeding.

Remember: Before undertaking any goose control, coordinate your activities with the appropriate authorities.

12-5. COMMON PIGEON OR ROCK DOVE (*COLUMBA LIVIA*)

Pigeons are well known to any city dweller. Their droppings deface buildings and create sanitation problems, and the acid in these droppings causes premature rusting and corrosion on some statues and exterior parts of buildings such as roof flashings and gutters. Their nests may also clog gutters and rain spouts. Occasionally, large numbers appear in rural areas, around feed mills and cattle or hog farms.

a. Life Cycle. In cities, pigeons move in flocks which may include several hundred birds that feed and roost together. Each female lays one to two eggs which hatch in 17 to 22 days. The young reach maturity in about four weeks but,

before this time, the female has laid more eggs, thus keeping up an almost continual breeding cycle.

b. Birds and Histoplasmosis. The close association of pigeons with people presents a potentially serious epidemiological problem since these birds harbor many diseases. Histoplasmosis, a systemic fungal disease is probably the most common.

- This is a respiratory disease that generally resembles a severe cold. It is rarely fatal.
- However, it often produces lesions of the lungs similar to those caused by tuberculosis.
- In acute cases the patient develops a high fever, and the liver and spleen become enlarged.
- The direct cause of histoplasmosis is a fungus frequently found in soil contaminated with pigeon droppings.
- People are infected when the contaminated dirt is disturbed and airborne spores of the fungus are inhaled or swallowed.

12-6. ENGLISH SPARROW (*PASSER DOMESTICUS*)

There are many species of native sparrows, but none are serious pests.

a. Identification. The bird commonly called the English sparrow, or house sparrow, isn't a sparrow at all, but is in the family *Ploceidae* which includes the "weaver finches" of the Old World tropics. English sparrows are small birds commonly seen in noisy flocks. They are pests in gardens, orchards, and around buildings where they build nests. Even in small numbers, they frequently drive small songbirds out of an area.

b. Nests/Eggs. English sparrow nests are almost always built in, on, or near buildings. Nests composed of twigs, grass, paper, and other materials are built in gutters, on roofs, under eaves, and inside buildings on roof supports, but only rarely in trees or shrubs. The English sparrow was introduced into the U.S. in the 1850s and is now found throughout North America. Five to six eggs are laid per brood and three to four broods are hatched per year.

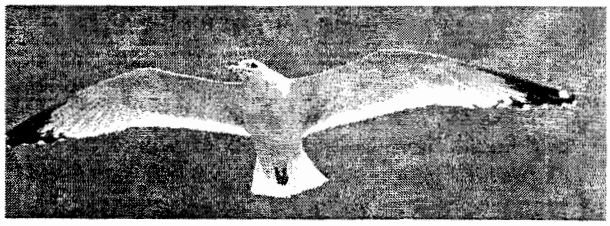
12-7. EUROPEAN STARLING (*STURNUS VULGARIS*)

a. Habitat. Starlings are pests in cities and rural areas, travelling in large flocks that sometimes contain a million or more birds.

- In rural areas, starlings nest in tree cavities and on ledges around farm buildings; they're usually bothersome around grain elevators, corn fields, fruit trees, and in cattle and hog feed lots.
- These birds normally spend the summer months in suburban or rural areas, but when it turns cold, they'll flock into towns and cities at night to seek the warmth and shelter of larger buildings, or roost on trees in residential areas and city parks.
- During the day they fly back to the country to find food, then return to the city again at night.

b. Group Mode/Life Cycle. Starlings fly as a group from their roost at the first sign of anything unusual such as a sudden noise or flashing lights. However, they soon learn to ignore any sounds or lights that pose no danger. Starling eggs are pale blue and there are three to six eggs per clutch. Twelve days are usually required for incubation, and the young stay in the nest two to three weeks. Two broods are usually raised each year. Starlings are quite hardy and able to survive under difficult environmental conditions.

12-8. GULLS (FAMILY LARIDAE)



a. Location. Several species of gulls cause problems at military runways and commercial airports where they use nearby fields as "loafing" areas.

- As planes take off and land, they may collide with the birds and serious accidents may result.
- Flocks of gulls are found in the Great Plains and Rocky Mountains of the U.S. Some common species are: (1) Herring gull, *Larus argentatus*; (2) Ring-billed gull, *Larus delawrensis*; (3) Laughing gull, *Larus atricilla*; and (4) California gull, *Larus californicus*.

b. Food Source. All gulls are omnivorous, meaning they eat both animal and plant material. As scavengers, they eat anything they can find. Gulls are commonly found feeding at garbage dumps or on refuse thrown from ships; on land they eat insects and seeds. After feeding, these birds like to "loaf" and will fly to an area near their food source to do so. Large flocks of gulls may be present in these loafing areas, and at airports this can be extremely dangerous.

12-9. MISCELLANEOUS SPECIES

Many other birds such as woodpeckers, swallows, and grackles can also be pests. No good general method of management has been developed for these birds. Again, it's imperative to contact the environmental office to adapt available legal management methods to each situation encountered.

12-10. MANAGEMENT

Managing pest bird populations is achieved mainly through permanent and temporary management techniques. Of the two, permanent management is the more desirable method and if economical and practical, is the method of choice. Temporary techniques can also help reduce pest bird populations but must be applied on a repetitive basis.

12-11. MANAGEMENT: PERMANENT TECHNIQUES

Permanent management techniques can be successfully used against starlings, pigeons, and English sparrows. Gull management is usually achieved by temporary measures because permanent management generally isn't effectively applied or economically used against gull populations.

a. Birdproofing New Buildings. The most certain way to keep pest birds off a building is to construct the building so there are no roosting or nesting spaces on it. This requires cooperation between pest managers, military engineers, and architects when the building is being planned.

b. Birdproofing Existing Buildings. Although it's usually impossible to make an entire building bird-proof, reducing roosting and/or nesting sites is possible.

- On existing ornate buildings or those with belfries, towers, overhanging ledges, etc., birds can be effectively screened out with wire mesh having openings not greater than one inch for pigeons, and 1/2 inch for English sparrows and starlings.
- When birds are indoors, all openings that can't be closed permanently should be screened in this manner.
- In buildings with open sides, screening can be dropped down from the edge of the roof to reduce the size of the opening and still make it possible to use the building.
- Where ledges aren't more than a few inches wide, light metal, such as sheet aluminum, can be installed at a 45° angle to give a surface where birds can't nest.
- There are numerous commercial products available to eliminate roosting sites.

12-12. MANAGEMENT: TEMPORARY MANAGEMENT TECHNIQUES

Temporary bird control is based on three main premises: repelling, trapping, or killing. Contrary to popular belief, killing local populations of pest birds does not adversely affect the species involved.

a. Repellents. Various "scare devices" have been installed on buildings to control birds. Stuffed owls, balloons, rubber snakes, tin foil streamers that flutter in the wind, and many other objects, have been tried. Many of these will work for a short time where bird populations aren't heavy, but when roosting or nesting space is at a premium, they're usually ineffective.

(1) Noise. Since birds are usually disturbed by sudden loud or unusual noises, many noise-producing devices are designed to scare them off this way.

- One such device is a small cannon that uses acetylene gas to emit loud blasts at intervals.
- Large vibrators, such as those used to shake flour from bins, have been installed on bridge girders, where the vibrations and noise discourage birds from nesting on these structures.
- Recorded distress calls may be effective in limited situations but haven't been effective over large areas. They work best when used as the flock is "staging," or preparing to roost for the night.

(2) Firecrackers/crackershells. Firecrackers, or crackershells, thrown or shot into bird flocks have been used effectively for dispersal. Since some birds will not return to an area where they've had a bad experience, this method works fairly well in limited situations.

(3) Glues/jellies. Various bird glues or jellies also keep birds away from buildings.

- Some are thick and tacky materials; others have a jelly-like consistency, and still others are thin enough to be sprayed.
- The lighter materials are more suitable for use on trees, although they can be used in many other situations.
- Heavy glues are usually applied with a putty knife or caulking gun.

(4) Disadvantages glues/jellies. Application of bird glues or repellents to buildings is a fairly effective way to discourage birds, but these repellents have some disadvantages.

- Where they're visible they deface buildings, and on window ledges they are a hazard to window cleaners.
- Also, their effectiveness is quickly reduced in dirty, dusty areas.
- Pigeons and starlings can be repelled from their roosting places with bird glue, but in nesting areas pigeons will frequently make a mat of sticks or straw over the glue and go on nesting as usual.

(5) Ammonia water. A weak solution of ammonia water may be used to discourage birds, particularly starlings.

- A fine mist of the solution is blown into trees or onto buildings when birds are roosting and when the temperature is near or below freezing.
- Applications for several nights are usually necessary to dislodge birds and treatments may be needed several times during the season. Mist treatments are easily done at a relatively low cost.

(6) Compounds. There are specially prepared compounds approved by the Environmental Protection Agency (EPA) for repelling birds.

- These compounds give good results in the management of most pest species and are especially effective against starlings and gulls.
- These chemicals are baits, and birds that ingest them become ill almost immediately, emitting distress cries that cause other birds to leave.
- Birds ingesting the bait are usually killed, but only a small percentage of the flock usually eats the bait.
- This method can be very effective in repelling gulls.

b. Trapping. Traps designed to capture birds unharmed are available in a variety of designs from commercial sources. Birds are attracted by bait, sometimes in combination with live decoys. Captured birds can be gassed or killed by other humane methods. In some cases, it may be possible to transport captured birds for release elsewhere. Use commercial live traps to capture domestic pigeons, starlings, or English sparrows.

(1) General information.

- Trapping is not practical over large areas or where large populations are present, but considerable numbers of pest birds can be removed from limited areas.
- If birds will not enter traps to feed, pre-baiting may be required. Birds are more easily attracted to bait in winter because natural food is less available. Starlings, however, do not usually feed near their roosts.
- Traps can be manufactured locally if resources are available. Each trap is designed to capture a particular species.
  - -- The designs include swinging-bob pigeon traps, funnel traps for pigeons, center-drop traps for starlings and English sparrows, funnel traps for English sparrows, and some novel designs.
  - -- Many models capture dozens of birds at once, and some have multiple chambers to increase their capacity and prevent escape.

(2) Placement of traps. Try to place traps where they will not be disturbed.

- Bait them (inside and around the trap) with appropriate food and ample water. Bait pigeons with whole corn; English sparrows with finely cracked corn; and starlings with cracked corn, peanut butter or apples.
- Check all traps daily. Several calm, healthy birds left in the trap as decoys will often increase efficiency.
- Handle protected species carefully and release them immediately.
- Non-protected birds causing a pest problem should be released at least 40 miles away.
- Incinerate dead birds.

c. Pigeon traps. Trapping is a successful way to control pigeons. The birds are captured alive in suitable traps in such places as city parks and on top of buildings. Use swinging-bob pigeon traps to help reduce the numbers of pigeons feeding, roosting, or nesting around buildings. Place traps near feeding or roosting locations, but where they will not be disturbed; a flat rooftop is often a good location.

(1) Trap placement. Watch the pigeons' feeding habits to spot suitable trapping locations. It they're feeding in open fields, place traps there. If they've been feeding near a runway, don't trap there, but try to lure them away. Post signs to keep people clear of the trapping area. Spread a food such as cracked corn or other grain around the door of the trap and put an ample supply of bait and water inside. Keep the cages open and prebait for 2 weeks to lure the pigeons to the food source and get them used to entering the traps, then activate the traps.

(2) Check traps. Over several weeks, check traps daily to remove captured birds for transport and release; leave two or three healthy birds as decoys and replenish food and water as necessary. Try to leave the same birds as decoys each time so they become tame. Leaving birds with distinctive color patterns will facilitate identification; brightly-colored birds also seem to be more effective decoy than dull birds.

(3) Trapped birds. Trapped pigeons should be destroyed humanely. Pigeons with leg bands or non-target species such as mourning doves can be released unharmed.

d. Modified Australian Crow Traps. The modified Australian crow trap is probably the most simple and effective live trap available. These traps can capture starlings, English sparrows, blackbirds, and other problem birds in a fairly small area.

(1) Trap design. They should be at least 8 feet long, 6 feet wide, and 6 feet high or even larger if practical. The entrance slots should be 1.75 inches wide. A 9-inch minimum clearance at each end is critical. Place traps in an open area rather than under trees.

(2) Establishing the trap. For starlings, bait the traps with rotting apples, finely cracked corn, of feed pellets. Try to bait with a food that the birds are used to eating. If one trap location or type of bait doesn't work, try another. The trap will be most effective with 10 to 12 decoy birds in it. Provide the decoys with fresh water. To make two suitable water containers, split an old rubber tire down the middle. Tend the traps regularly.

e. Nest-box traps. Nest-box traps are used to reduce local populations of starlings or English sparrows during their breeding season.

(1) Trap design. Nest-box traps come in several different designs. For starlings, the trap is smaller, but the opening is slightly larger. The front wall is put on last and fastened by screws to make repair easier. Glue pieces of hay and feathers to the back of the chamber, and use a tightly woven sack to receive the birds as they are captured.

(2) Trap placement. Place the trap on the side of a building or on a pole where the sack can hang freely and is easily reached with a ladder. Getting rid of existing nesting sites may enhance the impact of the traps. In a limited area, nest-box traps can effectively remove English sparrows or starlings, but they probably won't eliminate all the pest birds in any area.

f. Raptor Traps. If raptors (birds of prey) create a strike hazard and can't be discouraged with other measures (such as eliminating the food source), it may be possible to trap them with verbail pole traps or Bal-Chatri traps and then release them elsewhere. This takes the cooperation of the U.S. Fish and Wildlife Service. They'll provide the traps or the information needed to build traps.

g. Lethal Methods. Birds removed from traps should be disposed of humanely and out of public view to avoid negative reaction. Never take birds like pigeons, English sparrows, and starlings out in the country and release them; they'll only return to become a nuisance again. Take care to examine trapped pigeons before killing them to be sure no racing or tagged pigeons are killed. These birds will have an identifying leg band.

NOTE: Coordinate with the environmental office and wildlife authorities before enacting any lethal bird control program.

(1) Shooting programs. Only limited success has been obtained with shooting programs. As a general rule, shooting kills a small percentage of birds and drives many more away.

However, constantly changing legal requirements may affect the ability to exercise this option. If approved, shooting programs must be carried out continuously for best results. The limited residual effect and high cost of this type of management serve to make it one of doubtful value. Its best use is as a supplement to other more effective techniques.

(2) Poisoning programs. Poisoning programs are usually effective against pigeons and English sparrow populations, but are of little use against starlings. Using poisoned bait calls for great care to prevent destruction of non-target animals, including species of birds that don't require control. If baits are properly placed in or around buildings, there is little probability that birds other than the target species will be poisoned. Winter is the best time to poison pigeons since their natural food supply is low.

(3) Pre-baiting. Pre-baiting with nontoxic bait should precede the poisoning program to achieve good bait acceptance. Indoors, place poisoned baits on wide girders or other structural members of airplane hangers, barn lofts, and other spacious enclosed areas to obtain control without resorting to outdoor baiting. Shallow pans or trays of metal or wood to contain baits can be fastened to the rafters and girders. On sloping roofs, short, flat boards can be installed and the bait sprinkled on them.

(4) Toxic baits. Keep toxic baits under continuous observation when they're first exposed to make sure non-target birds aren't attracted to the area. Thirty minutes of observation is generally sufficient if pre-baiting was used. Poisoned baits are available commercially or from the U.S. Fish and Wildlife Service in a prepared, ready-to-use form. To eliminate potential safety hazards in mixing bird baits, purchase of prepared baits is recommended.

(5) Chemically treated perches. Another lethal method is use of chemically treated perches. Place these perches strategically throughout the structure so birds will roost on them. The chemical enters the body though the feet and kills the roosting birds in a relatively short time. Considerable hazards are involved in using such chemicals. Use them only after all other methods have failed and after approval is obtained. In any poisoning program, remember to immediately collect bodies of dead birds to eliminate any possibility of secondary poisoning of other animals.

Section II. BATS

12-13. INTRODUCTION

Bats require very different management considerations than do most other mammals. Nine families of bats are found in the U.S. and 17 worldwide. About 40 species occur in the U.S. Bats are found from north to south within the limits of tree growth, and up to 13,000 feet above sea level. Bats are effective insect predators, and in some situations are attracted to specific areas by the use of bat houses.

12-14. DESCRIPTION AND BIOLOGY

Bats are the only mammals that fly. Their bodies are covered with fur and they give birth to living young. A bat's wings are formed by skin stretched between the elongated bones of the front legs and toes and usually extending back along the body to the hind legs and tail.

a. Life Style. Bats normally roost in natural shelters such as caves and tree cavities or under overhanging rocks, but they can easily adapt to living in buildings where they roost in attics, hollow walls, chimneys, and similar places. A few species are solitary, but most congregate in large colonies so infestations are frequently severe.

b. Activity/Navigation. Bats roost in an upside-down position and don't build nests. Droppings and urine deposits under roosting areas have a strong ammonia-like odor that usually attracts new bats to the roosting areas even after the original infestation is removed. Bats are active during the evening hours. They leave the roost at dusk in search of insect prey. Although bats have poor vision, their hearing is acute. Bats navigate

by means of a sonar-like echo location system which helps them readily avoid objects even in total darkness.

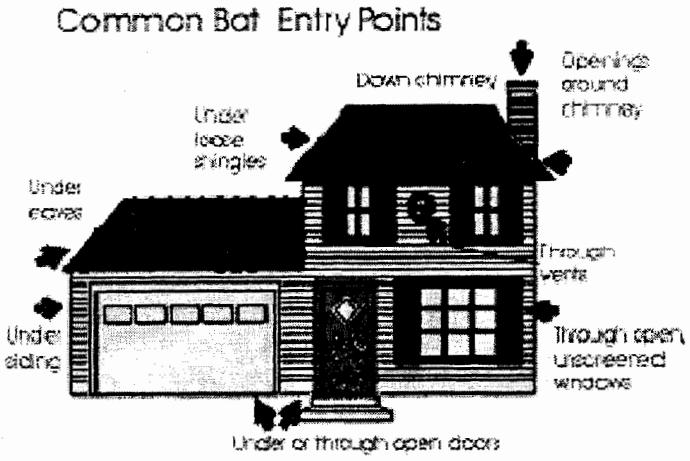
12-15. MANAGEMENT

Bat management is important in some situations since they may transmit rabies to humans. The actual rabies risk from bats is often overstated. It is estimated that only 1% of all bats in the U.S. are infected by rabies. In fact, there are only one or two human cases each year from all possible sources combined (skunk, fox, raccoon, bat, etc.). Bat feces (guano) can accumulate in great quantities under roosts causing damage to buildings and producing strong noxious odors. Bats also harbor numerous ectoparasites that can occasionally affect humans.

a. Chemical Repellents. When roosts are in an attic or any other easily reached, closed space and where chemical odors aren't objectionable, use either mothballs or moth flakes as repellents. Such chemicals usually drive bats outside even in the daytime, since the odor of these products is extremely offensive to them.

b. Plug Openings. Because bats are easily attracted to areas where other bats have been roosting, it's necessary to close all openings to the roost area.

- Smaller bats can crawl through openings as narrow as 3/8 inch so don't leave any openings larger than 1/4 inch.
- Large openings should be closed entirely with wood, oakum, metal or concrete, except where ventilation is required; in this case, use of 1/4 inch mesh hardware cloth is recommended..
- Be sure all bats are out of building before plugging openings. One way to do this is to close all but a few openings and then wait several days until the bats are accustomed to using those that are left. Then, when the bats are all out at night, plug the remaining openings.



d. The Last Resort. If bat control or elimination isn't possible using repellents or bat proofing, it may be necessary to destroy them. This can be accomplished through fumigation and must be done by trained and certified personnel familiar with fumigants and fumigation procedures. To prevent offensive odors, remove dead bats and their droppings from the premises whenever possible. Odors remaining from the roost can be masked by moth balls or one of the deodorants used to mask rodent odors.

EXERCISES, LESSON 12

REQUIREMENT. Answer the following questions by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. List four problems which are the result of birds inhabiting structures.

   a. _____

   b. _____

   c. _____

   d. _____

2. What is the direct cause of the disease histoplasmosis? _____
   _____
   _____

3. Are English sparrows, found in gardens, orchards, and around buildings where they build nests, pests? _____

4. Gulls who eat at fields near military runways can be a problem. Why is this?

   _____
   _____
   _____
   _____

5. Do you need a permit to control Canada geese with lethal measures?_____

6. Temporary birdproofing an existing building may involve installing sheet aluminum at a 45 degree angle on ledges to keep birds from _____ _____.

7. List four noise devices used to motivate birds to find another area in which to stay.

   a. _____

   b. _____

   c. _____

   d. _____

8. Why is bat management important in some situations?
   _____
   _____

9. List two chemicals which can drive bats out of attics in the daytime.

   a. _____

   b. _____

10. To batproof an opening that does not require ventilation, use _____,

    _____, _____,

    or _____.

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	LESSON ASSIGNMENT
LESSON 13	Biology, Identification, and Management of Rodents.
LESSON ASSIGNMENT	Paragraphs 13-1 through 13-25.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to Identify commensal rodents and their potential to transmit disease, then employ integrated pest management against them IAW AFPMB *Military Pest Management Handbook*, and TG 138, *Guide to Commensal Rodent Control.*
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the references listed above, you should be able to: 13-1. Identify the habits and characteristics of the house mouse, roof rat, and Norway rat. 13-2. Identify the appropriate techniques used to survey for rodents. 13-3. Describe the proper corrective actions to control rodents.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 13

BIOLOGY, IDENTIFICATION, AND MANAGEMENT OF RODENTS

Section I. DOMESTIC RODENTS

13-1. IMPORTANCE

Rodents are important not only because of the diseases they carry, but also because of the huge amounts of food they eat or contaminate each year. The U.S. Fish and Wildlife Service estimates that rats alone destroy all the food annually produced by 200,000 farmers in the United States. Some rodent-associated diseases affecting humans are plague, hantavirus, murine typhus, leptospirosis, rickettsial pox and rat-bite fever. It is easy to see that rodent management is important from both medical and economic standpoints. The three introduced murine or "Old World" rodents, the Norway rat (*Rattus norvegicus*), roof rat (*Rattus rattus*) and the house mouse (*Mus musculus*) are the most destructive rodents in North America.

TYPES OF MURINE RATS

- Norway rat
- Roof rat
- House mouse

13-2. DESCRIPTION AND BIOLOGY

Rodents are in the class Mammalia and order Rodentia. Mammals are warm-blooded vertebrates with body hair that suckle their young.

a. Rodent Teeth. Rodents are distinguished from other mammals by the location and shape of their strong, well-developed incisors or gnawing teeth. They have a single pair of incisors in both the upper and lower jaws that are separated from the molars, or chewing teeth, by a prominent gap.

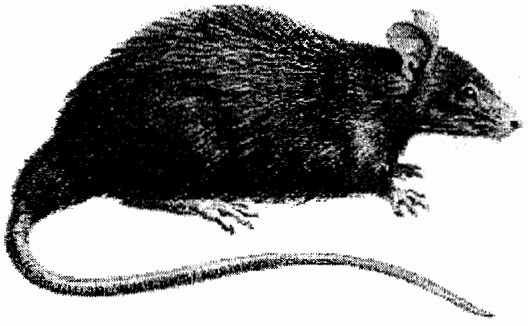
b. Rabbits and Hares - Another Class. Although rabbits and hares (*Lepus* and *Sylvilagus* spp.) have a similar tooth arrangement, they have an extra pair of incisors in the upper jaw. Because of these extra incisors, rabbits and hares are placed in the order Lagomorpha.

c. Murine Rodents. Murine rodents can be distinguished from native rodents and from one another by their tails. The tail of a murine rodent is generally more naked and scaly than those of our native rodents.

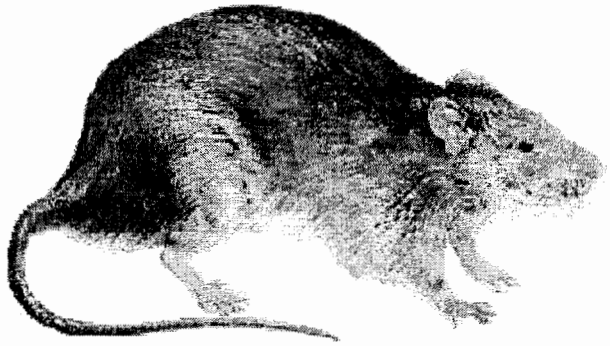
13-3. DISTINGUISHING CHARACTER-ISTICS AMONG THE NORWAY RAT, ROOF RAT, AND HOUSE MOUSE

The Norway rat, roof rat and house mouse differ in many obvious ways.

- Important distinguishing features between the Norway rat and roof rat are tail length and ear size.
  - -- The roof rat has a slender tail longer than the head and body combined. It has large eyes and large, naked ears.



  - -- The Norway rat has a tail shorter than its head and body combined. It also has small eyes and small, furred ears.



  - -- The house mouse is much smaller and has a finer fur than either the Norway or roof rat.

- To distinguish young rats from adult mice, check the size of their feet and head. Juvenile rats have conspicuously large feet and their head is large compared to their body size.
- A behavioral distinction is that young rats don't leave the nest or burrow until they are larger than mice.

13-4. HISTORY

a. The Spread of the Norway Rat. Rodents in the family Muridae are most abundant in eastern and southeastern Asia, and it's believed they're all native to Asia. They have now spread to almost every country in the world. The Norway rat was first reported in Europe in the 1700s and spread so rapidly that it was called "Wanderatte" or migratory rat by Central Europeans. It was transported to the United States about 1775, and quickly became established in seaports on the East Coast. In time, Norway rats spread throughout the temperate regions of North America.

b. The Spread of the Roof Rat and House Mouse. The roof rat is believed to have spread from Asia to Europe during the Crusades, and by the eleventh century this rodent was active in many parts of Europe. The roof rat was introduced to the New World around 1700 and was well known throughout the English, French and Spanish colonies. The house mouse with its smaller size and food requirements, has spread throughout much of the world and probably has the widest distribution of any animal except man.

13-5. GROWTH AND DEVELOPMENT

The birth and development of the murine rodents are very similar, so all three commensal species are discussed here as a group.

- The life cycle of rats and mice is fairly short and young animals mature rapidly.
- Female roof and Norway rats give birth about 22 days after mating.
- Gestation in house mice is only 19 days long.
- Rats and mice can mate within 48 hours after females give birth, so it's possible for rodents to be producing young almost immediately after young are born.
- If a female is nursing young and is also pregnant, birth of the new litter can be delayed up to seven days.

a. Rodent Litters. Large litters are the rule with rodents, and young rats and mice are in a precarious situation during birth and a few days thereafter. Rodent pups that survive accidents at birth grow very rapidly but are helpless in many ways.

- For example, their eyes and ears are not open, they're hairless, their legs are small and undeveloped, and they have no control over their body temperature.
- The Norway rat's ears open in about three days, but hearing doesn't develop until the rat is about 12 days old.
- On the other hand, a young house mouse may be sensitive to sound just four days after birth.

b. Rodent Development. In all three species, hair starts to cover the entire body in about a week and the eyes begin to open in 12 to 14 days. At this time, the young begin investigating their immediate environment. Young rodents gradually become familiar with their surroundings and undergo a "training" period in the company of their mother.

c. Rodent Education. The first few trips away from the nest are short, but soon the young rodents extend their trips until they eventually accompany the mother on her normal activities.

- During this period, they learn by association and by imitating their mother.
- By the time youngsters are three months old, they're extremely active and completely independent.
- This high activity level is continuous until the rodents are about nine months old; then old age begins and they slow down.

13-6. BEHAVIOR

a. Reaction to Strange Objects. Rats are very suspicious of any new objects or food found in their surroundings (neophobic). This characteristic helps them survive in dangerous environments. This avoidance reaction is important in control programs and is the reason for prebaiting prior to introducing poisons. Mice are not neophobic and often investigate new items in their environment.

- When rats or mice first begin to take new food, it's usually only in small amounts. If the animal is exposed to a sublethal dose of poison and becomes ill, the avoidance reaction is strengthened and a poisoning program becomes extremely difficult to carry out.
- If rats are very hungry or are in an environment where new objects and food are commonly found, such as a dump, the avoidance reaction may be reduced or absent.

b. Climbing, Jumping and Swimming. Roof rats, Norway rats and house mice are all capable climbers, although the Norway rat climbs only if necessary.

- Rats and mice can climb any vertical surface where they can get a toenail hold - even smooth surfaces if a pipe or other object is present that the rat or mouse can use to brace itself.
- They're also good jumpers. Some rats can jump up to three feet, and house mice have been known to jump as high as two feet.
- All three are good swimmers, especially the Norway and roof rats, which may swim up to ½ mile in open water.

c. Nesting and Harborage. Rats and mice nest close to food and water where harborage is available. They usually build nests in quiet areas offering good protection from predators.

- Rat nests are bowl shaped, about eight inches in diameter, and lined with soft materials such as cloth or cotton.
- House mouse nests are similar and differ only in size, being about five inches in diameter.
- Roof rats occasionally build their nests in trees, much like a squirrel does.

d. Burrowing Habits. The Norway rat, roof rat and house mouse all differ greatly in burrowing habits. Of the three, the Norway rat is the most capable and is adapted to burrowing. Its ears are small and hairs in the ear openings keep dirt out as it burrows.

- Roof rats will burrow only when Norway rats are absent, and the house mouse burrows only when other harborage is not available.
- Norway rat burrows are usually 1 to 1½ feet deep and about three feet long.
- Most nesting burrows of Norway rats will have several blind passages and one or more bolt holes used as escape exits.

e. Gnawing. Young rats and mice begin to gnaw when they're two or three weeks old and continue to gnaw throughout life.

- They must gnaw because their incisors grow at a rate of four to five inches per year.
- This growth allows continuous gnawing without wearing out the cutting edge of the teeth.
- Rats and mice will gnaw almost anything. In some cases, the only reason for gnawing is to keep the teeth short.
- To reach food, rats and mice will gnaw anything softer than their teeth.
- This includes materials like wood, cloth sacks, lead pipes, cinder blocks, asbestos and aluminum.
- Roof rats gnaw more than Norway rats.

13-7. FOOD HABITS

a. Food Eaten. Food choices by rats and mice depend on the environment the animals live in.

- Citrus fruits, for example, aren't a preferred food for rats, but in Florida the roof rat is a serious pest in citrus groves.
- Norway rats and house mice prefer meat, grain, cooked eggs, and potatoes.
- House mice occasionally feed on insects, which at times constitute up to 45% of their total diet.
- Rodents can be carnivorous and will attack live young animals.

b. Amount Eaten. The average adult rat eats about one ounce of dry food and drinks about one-half to one ounce of water daily. Mice, given their small size, don't need as much food or water and consume about 1/10 ounce of dry food and 1/20 ounce of water daily.

c. Feeding Habits. All three species have regular eating habits. These habits are based on the individual differences outlined above and the risk taken to get the food.

- Rats usually begin searching for food a little after sunset each day.
- Mice often come out in daytime to feed.
- All three species treat food the same way: they carry it to a hiding place before they eat it. They'll carry away small pieces of food a piece at a time. Larger pieces are dragged to cover.
- Rats and mice will eat in the open only if starved, if no enemies are around, or if the pieces are to big to move.

(1) Nibbling. Rats are fairly steady eaters, while mice are "nibblers," eating a little bit here and there. This nibbling habit explains why pest managers should put numerous poison baits close together to make sure the mice ingest enough poison to kill them.

(2) Baits. Laboratory studies have found that rats become satiated on one food and will no longer work to obtain it, but they will work to obtain something different.

- Occasionally use different baits to increase the probability of the bait being eaten.
- Another method is to make several different baits available to allow the rat or mouse to vary its diet.

13-8. SENSES

a. Touch. Touch is one of the first senses rodents develop and is important through their life span, especially since they're most active at night.

- In addition to their normal tactile senses, rats and mice have highly sensitive whiskers and guard hairs. At the base of each whisker is a complex nerve net that provides a high degree of sensitivity.
- Rats and mice prefer to run along walls or between objects so they can keep body contact with the sides.
- Long guard hairs are scattered over the body and are more sensitive than shorter hairs in the rodent's fur.

b. Vision. Rodents have poor vision beyond three to four feet but are very sensitive to motion 30-50 feet away. They're also colorblind, a helpful characteristic in a control program. If other non-target animals eat rodent bait, use colored baits to give a warning. The most attractive colors to rodents are yellow and green, which appear to be light gray to them.

c. Smell. Rats and mice have a keen sense of smell and they rapidly follow rodent body odor. A misconception many people have about rodent trapping is that no rodent will approach a trap with a human odor on it. This idea is false since rodents live so close to people that they are not afraid of human odors.

d. Taste. Rodents have a good sense of taste. As a rule of thumb, food acceptable to people will also be acceptable to rodents. "Bait shyness" doesn't occur because of taste but because the rodent associates the bait with becoming ill. Rodents will eat decayed food, but only if there's no other food available.

e. Balance. Rodents have an excellent sense of balance. If one is tossed into the air, it will almost always land on its feet. Rodents have fallen as many as two or three stories without being injured.

f. Hearing. Since rodents carry out most of their activities in the dark, hearing is very important to them. They have a well-developed sense of hearing and strongly depend on it.

Section II. RODENT SURVEYS

13-9. PRE-MANAGEMENT RODENT SURVEY

Before starting management actions against a rat or mouse infestation, first determine

whether rats or mice are present, the species involved, the size of the rodent population, and where most rodent activity is occurring. To get this information, survey for various rodent signs such as droppings, runways, gnaw marks, burrows, and nests.

13-10. DROPPINGS

The most frequent sign of rat or mouse infestation is droppings. Rat feces vary from 1/4 inch long by 1/16 inch in diameter to 3/4 inch long by 1/4 inch in diameter. House mouse droppings are very small, about 1/8 inch long and pointed at both ends.

a. Information from Droppings. Pest managers should notice the age of the droppings to determine if a building is currently infested. Fresh droppings are soft enough to be pressed out of shape and usually look shiny and moist. Color varies but is normally black or nearly black. Within three to four days, depending on weather conditions, droppings become dry and hard.

b. Location of Droppings. The quantity and size of droppings in an area may give an indication of the number of animals present. Fresh droppings of different sizes found in the same area usually indicate that reproduction is occurring; this is typical in extensive infestations. Feces are usually found along runways, near harborages, and in secluded corners. Rodent burrows and nests are very clean and have no droppings. In fact, people have seen rats and mice carrying feces away from nests and burrows.

13-11. RUNWAYS, RUBMARKS, AND TRACKS

Because rodents usually occupy a very limited area, they use the same paths or runways consistently. These runways usually lead to building entrances, harborages, or food and water.

- If outdoor runways are used extensively, they're easily seen in dense vegetation or even on bare ground.
- Runway locations are usually along walls, under boards, behind litter, and in other sheltered situations, so don't neglect these areas during surveys.

a. Rodent Rubmarks. Runways in buildings often have rub marks; greasy deposits left by the rodent's body as it rubs against a wall, climbs a pipe or passes through holes. These are often called swing marks when roof rats make them under rafters. House mouse runways may be anywhere and are the most difficult to find because they are small and have faint outlines.

b. Rodent Tracks. To easily see tracks, lay a flashlight down on its side. Tracks are best seen by side illumination and not by direct overhead light.

- Rat tracks are fairly large and the hind foot may be up to 1½ inches long.
- Mouse prints are considerably smaller, rarely being even ½ inch long.
- To determine the age of a rat or mouse run, notice its appearance. A heavily used run will be hard packed, shiny and free of litter. Fresh rub marks are soft when scratched, but old marks are brittle and will flake off. Outdoor tracks are usually fairly new; weathering will quickly erase them from view.
- The age of indoor tracks is hard to determine and such tracks are best observed by using tracking powders.
- By tracing rat and mouse runs, the harborage, food and water supply and means of entry into buildings may be revealed, greatly aiding control measures.

13-12. GNAWING

Signs of gnawing are among the best indications of rodent presence, if the gnaw marks are fresh.

- A newly gnawed wood surface has a fresh, light colored appearance.
- The edges of freshly gnawed pieces of wood will have sharp edges and show individual tooth marks.

- Rats will smooth and enlarge holes they pass through, and a smooth hole indicates it's an old and much traveled route.

13-13. BURROWS

Rodent burrows have two main uses, either as nesting/hiding places or routes of entry to a structure.

- Nesting and hiding burrows are usually 12 to 18 inches deep, may extend several feet in a horizontal direction, and often connect with other burrows.
- To gain entrance to buildings, rats may burrow up to four feet vertically to pass under a foundation wall.
- Norway rats prefer to live in the ground and their burrows are easy to find and identify.

a. Location of Norway Rats. Look for Norway rat burrows along foundation walls, around outbuildings and in dirt basements. Away from buildings, it's possible to find burrows in embankments, hedgerows and under dense vegetation.

b. Location of Roof Rats and House Mice. Roof rats seldom burrow at all, and house mice don't usually borrow around buildings. House mice commonly burrow when they live away from buildings or in fields. Mouse burrows are about one inch in diameter; rat burrows average three inches in diameter.

13-14. MISCELLANEOUS SIGNS

Occasionally, it's possible to use urine stains and other signs in rodent surveys.

- Urine stains are easily detected with an ultraviolet light, although other materials will also fluoresce under ultraviolet light. Evidence from stains must be verified with other signs of rodent infestation. Portable black lights are valuable tools for surveying for runways indoors.
- Hairs are not a very good indicator of rodent infestation because of the detailed analysis and special preparations required for identification. It's better to rely on other easier methods to tell whether rodents are present.

Section III. PREVENTIVE MANAGEMENT

13-15. PERMANENT RODENT MANAGEMENT

To manage rodents, don't depend on trapping and poisoning programs alone. Permanent rodent management is achieved only through a combination of preventive measures such as sanitation, and corrective measures to include trapping and/or poisoning.

- Sanitation is the first element in any rodent prevention program, and it's the only measure that ensures long-term rodent suppression.
- Without sanitary maintenance, rodent populations will continue to recover to their original or even larger levels once poisoning and trapping programs end.
- Always note and report any sanitation problems encountered.

a. Sanitation. For rodent management, sanitation involves proper storage of edible materials and disposal of all garbage and rubbish in rodent-proof containers. Structural harborages such as small, protected enclosures and double walls should be eliminated. Even in a rodent poisoning program, sanitation plays a major role.

b. Rodent Proofing. Rodent proofing is the construction of temporary or permanent barriers to rodent entry. This type of management though effective, may not always be possible. It is preferable to all other controls when and where it can be used. One example of rodent proofing is on docks where rat shields are placed on ship ropes and cables to keep rodents from entering the ship. In many countries, rat shields are mandatory, but whether they're required or not, it is good pest management practice to use rat shields on all cables or ropes connecting military vessels to docks.

13-16. BUILD/MODIFY STRUCTURE TO PREVENT EASY ACCESS

If a structure is built or modified in a way that prevents easy access by rodents, rodent management becomes much easier. In some environments, it may be essential to obtain any meaningful degree of management.

a. Openings. In areas where rodents must be eliminated, doors and windows should be made of or covered with metal.

- All holes in a building's exterior should be sealed.
- Rats can gnaw away wooden doors and windows in a very short time to gain entrance.
- They can enlarge openings in masonry, especially if the mortar or brick is of poor quality.
- All openings more than 3/4 inch wide should be closed, especially around pipes and conduits.
- Conduits themselves should be limited, if possible to a size smaller than 3/4 inch.
- Cracks around doors, gratings, windows, and other such openings, should be covered if they're less than 4 feet above the ground or accessible from ledges, pipes, or wires.
- Sheet metal of at least 26-gauge, 1/4 inch or ½ inch hardware cloth, and cement are all suitable rat resistant materials, although ½ inch hardware cloth has little value against house mice.

b. Building Construction. Rodents should be considered when planning any new construction or building renovations.

- Doors should be self-closing and should fit tightly.
- Double walls and space between walls should be blocked with fire stops; these stops, as well as the beams supporting floors should be constructed so they can't be used as rodent runways.
- In building for rodent prevention, it is important to remember that rats can routinely jump 2 feet vertically, dig 4 feet or more to get under a foundation, climb rough walls or smooth pipes up to 3 inches in diameter, and they routinely travel on electric or telephone wires.

Section IV. RODENT CONTROL

13-17. MULTIPLE-DOSE RODENTICIDES

a. General Characteristics. Some common anticoagulants include chlorophacinone, brodifacoum, bromadiolone, and Warfarin. Anticoagulant rodenticides kill by reducing the blood's ability to clot eventually causing internal bleeding. Since they affect all warm-blooded animals in this way, take precautions to keep humans, pets and domestic animals from eating baits containing these poisons.

- Anticoagulants are tasteless, odorless and stable in bait formulations.
- Most older single-dose poisons kill rats and mice soon after ingestion, but most newer anticoagulants must be ingested in small amounts for several days before they're effective.
- Even when weakened, rodents apparently don't associate their loss of strength with their food supply.
- This means that the problem of bait shyness commonly associated with older "one-shot" or single dose poisons is largely overcome.

b. Bait Enhancement. Anticoagulants generally provide maximum kill between the fourth and ninth nights after rodents start eating the poisoned bait. If necessary, bait continuously for two weeks or more to get effective management. For house mice, continuous baiting for at least a month may be necessary, because of the nibbling habit discussed earlier.

- Consider using water and food baits to increase program effectiveness.

- When starting a poisoning program where rodents are well established, first try to eliminate all existing food sources that match the form of the rodenticide.
- For solid rodenticides, remove all readily available food sources such as spilled food.
- Before using liquid bait, work to dry up all existing water sources such as leaking pipes or dripping faucets.
- As long as there's an adequate supply of food and water from other sources, there may be nothing to draw the rodent to the rodenticide.

c. Rodent Resistance to Anticoagulants. We've known of rodent resistance to anticoagulants since 1958. The first cases of Warfarin-resistance occurred in Europe, and resistance has also been found in many parts of the U.S. Resistance to one anticoagulant, such as Warfarin, often results in cross-resistance to a number of anticoagulants. If anticoagulant resistance exists in the local area, build a chemical control program around trapping and single-dose anticoagulants or other single-dose poisons to gain control.

13-18. SINGLE-DOSE RODENTICIDES

The single-dose, or acute, rodenticide group includes pesticides such as bromethalin, zinc phosphide, strychnine, and others. Each of these poisons has unique uses, characteristics, and dangers. Use these products carefully since they often have a moderate to high mammalian toxicity.

13-19. FUMIGANTS

In rodent management, fumigants are used to treat rodent burrows. An advantage of fumigants is they kill rodent ectoparasites as well, a factor of great importance when control efforts are meant to manage diseases such as plague and murine typhus. Fumigants are normally dispensed as tablets placed in burrows.

-- CAUTION --

Never use fumigants if burrows are near a building or a burrow travels under any building occupied by humans or non-target animals.

13-20. SELECTING AND PREPARING BAITS

The success of any rodent poisoning program depends upon the rodent accepting the bait, so select and prepare baits carefully. A poison bait contains a rodenticide, a food, a filler or binder, and sometimes an emetic to protect non-target animals.

a. Bait Materials. Bait materials may include such items as fresh meats, fresh or canned fish, cornmeal, corn, hulled oats, rolled oats, cracked wheat, bread, cake, chicken feed, seeds, apples, bananas, peaches, pears, pineapples, melons, nutmeats, candy, etc.

- Try to restrict baits to foods normally available to the rodent population.
- Using rolled oats or dog food in an area where the rodents' main diet is fish and bone meal may compromise a control program's effectiveness.

b. Rat Food Preferences.

- As a general rule, Norway rats prefer baits of meat and fish.
- Roof rats prefer fruits and vegetables. Both readily accept sweets, grains, and nutmeats.
- House mice prefer sweets, grains, seeds, peanut butter, cheese and sweet potatoes.
- Baits should be fresh for ready acceptance by rodents, so prepare them in amounts small enough for immediate use.

- A binder of vegetable, mineral or fish oil is often added to cereal or dry baits to hold the rodenticide and bait together and to aid in mixing.

13-21. BAIT PLACEMENT

Locate baits where rodents will come in contact with them. Choose sites along walls, runways, and where cover exists.

- Place bait mixtures in tamper-proof bait stations.
- Anticoagulant mixtures are usually exposed for at least two weeks, but a high re-infestation rate will require baiting on a permanent basis.
- A very important point in single-dose baiting programs is to be generous with baits. Rodents have a limited home range and too few baits, or baits poorly placed, will be ineffective.
- Bait liberally where there are recent and numerous signs of rat activity.

13-22. BURROW FUMIGATION

Fumigating rodent burrows is a relatively safe control and, if done properly, is quite effective.

- Fumigated burrows shouldn't be too close to occupied structures.
- One method of burrow fumigation is to close all other entrances to the burrow with earth and introduce the fumigant through one opening. One way to do this is to apply a dust first and then seal all burrow entrances from which dust emerges. Rats may escape if all openings to the burrow system aren't closed.

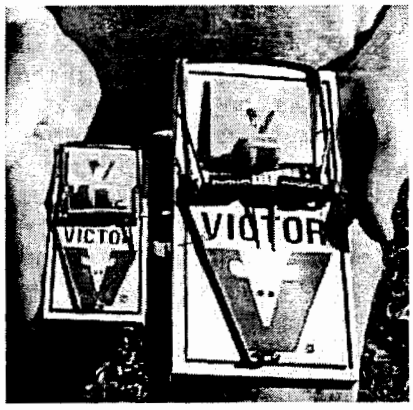
13-23. RODENT TRAPPING

Traps have a definite place in any rodent control program.

- Use traps exclusively where poison baits would be too dangerous or to avoid side effects such as dead rodent odors.
- This is extremely important when controlling mice as they are likely to die inside the building where they nest. For this reason, trapping is often the preferred technique for control of mice in buildings.
- Traps are also useful where populations of bait-shy rodents are present and when live rats are needed for ectoparasite recovery or other survey needs.

a. Common Traps.

(1) Snap traps/steel traps. The most commonly used traps are snap traps and steel traps.



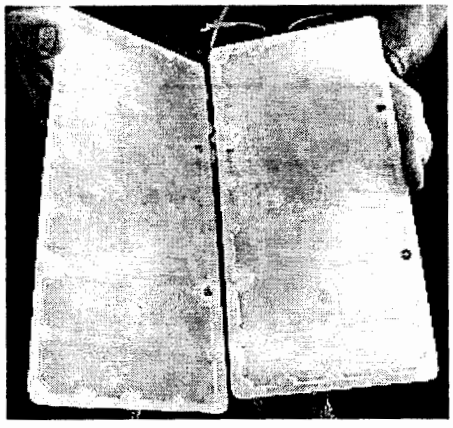
- Snap traps, sometimes called wood or break-back traps, have a flat wooden base and kill by means of a spring-loaded heavy wire bar and trigger. These are the traps commonly used by the general public.
- Steel traps have platform triggers and two steel jaws that are snapped together by a single flat spring.
- Rodents caught in these traps are usually killed immediately.

(2) Sticky traps or glue boards. There are numerous commercial sticky traps available. Bulk glue is also available to make your own traps. These can be very effective in a rodent management program and often work in situations where other traps or baits fail.

- Don't use glue traps in areas where there is excessive dirt, dust, or water. These

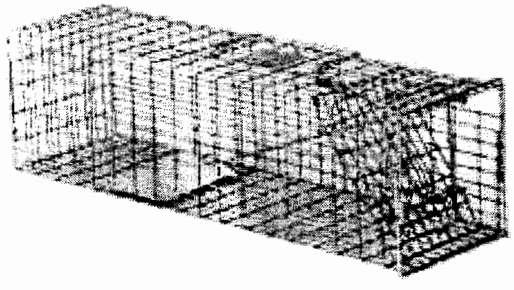
reduce trap effectiveness. Boards may also be less effective in extremely hot or cold areas.

- Glue traps are generally more effective for trapping mice since larger, stronger rats have a better chance of pulling away from all but the toughest glue traps. Use glue traps in the same manner as described for snap traps.



NOTE. Because these traps also catch non-target small animals, they aren't recommended for use in military programs.

(3) Cage traps. Use cage traps when live trapping is needed, such as in ectoparasite surveys.



- Several types of cage traps are available. These traps have an entrance chamber and a bait chamber with an opening by which a rat can enter but not exit.
- Cage traps are generally more readily accepted if completely camouflaged except for the rat entrance.
- A box trap is a wood or metal box open at one or both ends, having one or two doors that are sprung or released by a lever fastened to a trigger.
- These traps are similar to those used to catch rabbits or other animals.

b. Using Traps. Snap traps can be used with or without bait.

- When using baits, fasten solid bait about the size of the index finger securely to the trigger.
- Ground baits may be used but are difficult to attach securely.
- To use a material such as peanut butter, first impregnate it into a piece of gauze, then tie the gauze to the trigger.
- Place baited snap traps in or very near rodent runs and at right angles to the wall, with the baited end toward the wall (the bar should snap towards the wall).
- One effective technique is to place traps on both sides of entrance holes so rats can go in either direction and still be trapped.
- Rats can often be captured in homemade traps. Pour commercially available bulk glue into larger containers such as box lids.

c. Rodent Disposal. It is important to monitor rodent traps regularly. Dispose of dead rodents in a landfill or by incineration. Live rodents should be humanely killed. Do this by asphyxiation with carbon dioxide or chloroform. Rodents can also be drowned in a bucket of water.

Section V. ECTOPARASITE CONTROL

13-24. RODENT CONTROL REQUIRES ECTOPARASITE TREATMENT

In addition to rodent management, it's also necessary to manage their ectoparasites. Arthropods such as fleas and mites are important links in transmitting many rodent-borne diseases to people and these pests must be controlled along with their rodent hosts.

- The first step in treating an area or building for ectoparasites is an inspection for signs of rodent activity.
- Treat all runways, burrow entrances, and nests with an approved pesticide dust. Include vertical surfaces rodents may brush against.
- Rodents that contact the dust carry it on their feet and fur to nests and other areas beyond the reach of normal dusting activities.

13-25. EXTERMINATE ECTOPARASITES FIRST

If ectoparasite control is needed, dusting should precede rodent poisoning for at least one week. If separate treatments for rodents and ectoparasites aren't practical, an alternate method is to dust runways and apply poisons that are slow acting; ectoparasites are killed before rodents succumb to the rodenticide.

EXERCISES, LESSON 13

REQUIREMENT. The following exercises Are to be answered by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. Rats and mice are good jumpers. Some rats can jump up to __ feet; mice have been known to jump up to __ feet.

2. Rats and mice will gnaw through anything softer than _____; for example, materials like cinder blocks, lead pipes, asbestos, and wood.

3. Rats can survive in dangerous environments because _____

_____

_____

_____

4. Rodents will approach a trap with human odor on it because _____

_____.

5. What kind of illumination is the best way to see rodent tracks? _____

_____

_____

6. The only preventive measure that ensures long-term rodent suppression is _____.

7. Rodents, even when weakened, continue to eat anticoagulant contaminated food supply because _____

_____

_____

8. Rodents accept cage traps more readily if

_____

_____

_____

9. Anticoagulants usually provide maximum kill between the ___ and the ___ nights after rodents start eating the poisoned bait.

10. Before rodent poisoning, control ectoparasites such as fleas and mites because

_____

_____

_____

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LESSON ASSIGNMENT	
LESSON 14	Management of Miscellaneous Vertebrate Pests.
LESSON ASSIGNMENT	Paragraphs 14-1 through 14-27.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to employ integrated pest management practices for the control of vertebrate pests IAW AFPMB *Military Pest Management Handbook.*
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the reference listed above, you should be able to: 14-1. Identify the diseases for which specific vertebrates are the reservoir. 14-2. Identify the animals that may become pests on military installations. 14-3. Identify the appropriate control measures for management of these vertebrates.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 14

MANAGEMENT OF MISCELLANEOUS VERTEBRATE PESTS

Section I. MOLES

14-1. INTRODUCTION

Most small animal problems on military installations are from domestic rodents, but other field rodents and animals must also be managed. These animals are usually native to the area and don't normally live in close association with people, but can nevertheless damage military equipment and supplies.

14-2. IDENTIFICATION

Moles are burrowing insectivores that spend most of their time underground. There are several different genera of moles, but most common pest moles in the U.S. are in the Genus *Scalopus*. Moles feed on earthworms, grubs, cutworms, beetles, and other harmful underground pests. They may also mix and aerate soil, and assist water penetration to plant roots. However, their tunneling activity can damage turf, so occasionally mole management may be justified. When the soil is moist and invertebrates are abundant near the surface, moles use their short, powerful, hand-shaped front legs to push aside and elevate the soil, forming the characteristic mole runs or ridges. In summer and other times when the ground is dry and food is scarce near the surface, they burrow deeper and push out piles of

loose, dirt, which are frequently mistaken for gopher damage.

14-3. DEVELOPMENT

Moles are extremely active animals and consume large amounts of food daily. As a general rule, they select a protected place to nest. Fence rows, foundation walls, piles of debris, old stumps and bases of trees often give favorable harborage. Young moles are born in early spring in litters of three or four. The young grow rapidly and by early summer are almost full-grown.

14-4. EVIDENCE OF MOLES

There are no special inspections for moles.

- Their presence is evident from their digging.
- Make small breaks in runs and check these at short intervals throughout the day. Actively digging moles will repair the breaks when they encounter them.
- Moles work at all times of the day and night, especially in seasons when there is little variation in temperature.

14-5 MOLE MANAGEMENT

There are many misconceptions about mole control. There is no one simple solution, but there are effective methods available.

a. Limiting Food. Many people believe that indirect mole control is possible in turf areas by using insecticides that control the beetle grubs and other lawn insects they eat. The moles presumably avoid the area because of the absence of food. However, most insecticides labeled for grubs do not control the moles primary food source (earthworms), and mole populations are not reduced by insecticide treatments.

b. Trapping. This is a universally applicable and satisfactory method of mole control, but it's successful only if pest managers first consider the mole's habits and instincts. The suspicious mole is aroused when its sensitive nose encounters anything foreign in its runway. It will immediately back up and burrow around or under an ordinary trap set in it tunnel. But it's not suspicious of dirt blocking the runway, this being a more common occurrence. It will immediately push its way into such a dirt blockade.

(1) Trapping on or in dirt. This characteristic permits use of a trap that straddles, encircles or is held suspended above the runway, with a trigger pan resting on or hidden in the dirt blockade. The unsuspecting mole pushes into the dirt obstruction, either lifting the trigger pan or pushing the dirt against the hidden trigger arm, releasing the trap spring. Always remember the mole is sensitive to an unnatural environment. Never tear up large parts of a burrow trying to find a good spot for a trap.

(2) Placement of traps. Keep in mind that a poorly set trap is a detour sign for moles. Selecting a frequently used runway for a trap is of prime importance. East of the Rocky Mountains, place traps in the hunting tunnels; such tunnels are close to the surface and have conspicuous ridges. Since these surface runways are made mainly to find food, many aren't used more than once. Others, however, serve as highways and are used regularly.

(3) Commercial traps. Mole traps on the market are either the gripping type or the harpoon type. Gripping traps come in several designs, including the choker-loop trap, the scissors-jaw trap, and the diamond-jaw trap. All are about equally effective.

c. Fumigants and Repellents. Aluminum phosphide tablets and pellets can be used with some success for mole control. Moles have a great ability to avoid poison baits, repellents may be a more practical option in small, restricted areas of lawns or gardens. Moth crystals are anecdotally effective. Open the visible runways with a finger or a small stick. Insert a teaspoonful of one of these materials and close the opening carefully. Make applications at intervals of 8 to 10 feet along raised runways and repeat whenever sections of old runways show signs of use or when ridges appear.

d. Ineffective Techniques. As with many pests, there are a variety of "home recipes" and ineffective products marketed for control. These include sonic or ultra-sonic repelling devices, castor oil, and grain-based poisons.

Section II. GOPHERS

14-6. IDENTIFICATION

- Gophers in the United States generally belong to two genera: *Geomys* spp. in the eastern U.S. and *Thomomys* spp. in the West.
- They're well suited for underground living and are rarely seen out of their burrows.
- Their forelimbs are greatly enlarged for digging, and large, heavy incisors protrude beyond the lips.
- On each side of the mouth are openings for fur-lined, external cheek pouches.
- Their ears are minute, and the eyes are small.
- The tail is naked and has a tactile tip. Pocket gophers feed on roots, tubers, bulbs, and other vegetables.
- They burrow extensively, pushing earth up to form above ground, fan-shaped mounds.
- They make both main and lateral tunnels, and a single gopher searching for food may extend it tunnels to cover an acre or more.

14-7. GOPHER MANAGEMENT

a. Trapping. Because pocket gophers live in small underground burrows, special traps are needed. The most successful trap is the Macabee; it's about 5 ½ inches long and made of wire except for the trigger. It springs when a gopher pushes against the flat trigger pan. The next most popular is a box type with a choker loop that releases when the gopher seizes special bait on a trigger. Traps are quick and effective when they're set right. They're inexpensive, last indefinitely, and simple to use, but the labor of setting them is a problem. The trapper must locate main burrows (side burrows may not be revisited), and some excavation is required to set the traps correctly.

b. Fumigation. Fumigation, a successful method for controlling some rodents, is of limited effectiveness against pocket gophers. The extent of the burrow system, the chance for leakage through the softer earth of laterals, the closeness of the main runs to the surface, and the fact that gophers may quickly plug off their burrows to escape poisonous gas all make fumigation unsatisfactory.

c. Flooding. This method may drive gophers from their runways, but few actually drown. To force out individual gophers in lawns and gardens, turn the stream from a hose down the burrow so the gopher can be killed as it emerges. A variation of flooding involves adding a high-suds laundry detergent to the water. As the water is sprayed in, suds develop ahead of the water. This action gets the same response from the gopher but uses less water.

d. Exclusion. It's possible to use fencing to protect small gardens or ornamental plantings of high value. To protect against both underground and overland invasion, the fence of small-mesh wire, sheet metal or concrete should extend a foot above the ground and 2 feet below. Protect young trees or grapevines by enclosing them in a wire-mesh basket or cylinder from ground level to 2 feet deep. Cases of unusually heavy and persistent burrowing in canal and ditch banks may require underground fences of wire mesh or concrete, but this is expensive and is warranted only when gopher damage is quite extensive.

e. Poisoning. Pocket gophers are effectively controlled by poisoning. Over large areas heavily infested with gophers, the cheapest control is poison bait. Probe to locate an open burrow, then drop poison bait through the probe hole. Take care not to drop dirt into the tunnel or cover the bait with dirt. Use stomach poisons available on the market; pocket gophers' external cheek pouches are lined with fur and don't absorb poison.

Section III. PRAIRIE DOGS

14-8. IDENTIFICATION

These large rodents are in the genus *Cynomys* and are generally restricted to the western U.S. and Mexico. They have short hair that lies close to the body. The head and back are tan to light brown. Prairie dogs are diurnal and are truly colonial animals living in social groups called "towns". They mainly feed on vegetation but will also eat insects. They dig deep burrows and may be dormant for short periods during cold weather. Populations may vary from 5 to 35 per acre and individuals can live as long as 8 years under ideal conditions.

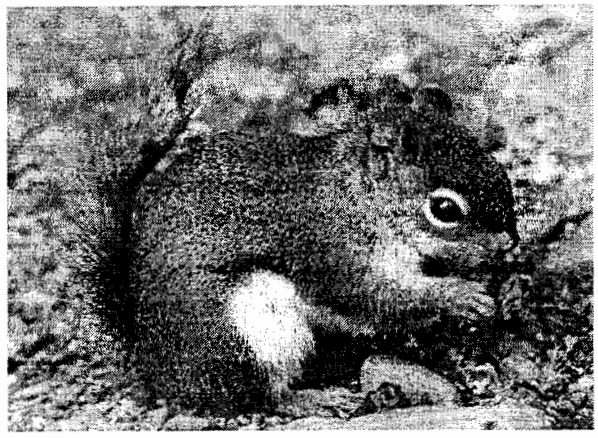
14-9. ON MILITARY INSTALLATIONS

The major concern with prairie dogs on military installations is their role as reservoirs of plague and tularemia. This can be a major problem if their towns are located in training areas where plague is endemic.

14-10. PRAIRIE DOG MANAGEMENT

Check with appropriate authorities prior to conducting prairie dog control. There may be endangered species, such as black-footed ferrets and burrowing owls in association with prairie dog towns. Toxic baits are the most cost effective prairie dog control method. Pre-baiting is an important part of the program to ensure bait acceptance. Fumigation may also be effective, and has the added advantage of killing ectoparasites in the burrow. Fumigation will only kill animals underground. Those on the surface will not be harmed.

Section IV. TREE SQUIRRELS



14-11. IDENTIFICATION

There are various genera of tree squirrels in the Family Sciuridae, such as fox, gray, red, black, and flying squirrels. They usually nest in trees but may enter buildings under favorable conditions. Indoors, their noisy habits and ability to chew wood and even electrical wiring can cause considerable annoyance and damage. In this event, first determine how they're entering and seal all existing openings with ¼-inch hardware cloth or sheet metal. Try to seal openings when squirrels are absent. If this is not possible, trap and remove them.

14-12. REPELLING SQUIRRELS FROM BUILDINGS

To repel squirrels from buildings, liberally apply naphthalene flakes or moth balls in enclosed spaces such as attics. These are anecdotally effective. Squirrels may also enter a building from over hanging tree limbs. In this situation, simply prune the limb back six feet or more so they can't reach the building. Ensure that all entrances to a building are well sealed. Even openings smaller than a squirrel can enter may be gnawed and enlarged. Metal flashings and screens may be

effective exclusionary devices. When screening,repellents, or removing tree limbs don't solve theproblem, trapping and/or killing the squirrels may be necessary. There are currently no fumigants or toxicants federally registered for squirrel control.

Section V. GROUND SQUIRRELS

14-13. IDENTIFICATION

Ground squirrels in the United States belong to the Genus *Spermophilus*. Similar genera occur in Europe and Asia. They range in size from 9 to 19 inches and are gray to reddish-brown in color. Most species have large ears, a rather long and narrow skull, well-developed cheek pouches, and long, furred tails.

14-14. MILITARY CONCERN

Ground squirrels may burrow extensively and sometimes make temporary burrows to extend their foraging area. Their tunnels and tunnel-making activities pose the greatest problem to the military, although they can also carry ectoparasites and serve as reservoirs for diseases like Colorado tick fever and leptospirosis. They may also carry plague. They're commonly serious pests around airstrips and bunkers, where their burrowing activities can cause the strip or bunker mounds to collapse.

14-15. TREE SQUIRREL MANAGEMENT

Ground squirrel control is similar to that of gophers. Toxic grain baits and fumigants, as well as trapping may be effective management techniques. There are no effective ground squirrel repellents. Fencing is another option for small areas. The fence should be buried at least 6 inches beneath the soil surface.

Section VI. HARES AND RABBITS

14-16. IDENTIFICATION

Hares and rabbits (order Lagomorpha) differ from rodents in that they have four upper incisor teeth rather than two. The second pair of incisors is smaller than and behind the first pair. These are heavily furred animals with long ears and hind legs. They inhabit most of the major land masses of the world, as well as some islands.

14-17. TRUE RABBITS

True rabbits belong to the genus *Sylvilagus* and are represented by cottontails, which range from southern Canada south to Argentina and Paraguay; the smaller brush rabbit of the U.S. Pacific coast; and masses or swamp rabbits of the south and southeastern U.S. Newborn rabbits are completely naked and helpless.

14-18. HARES

Hares are in the genus *Lepus* and are represented in the U.S. by the jack rabbit, snowshoe hare, and their relations. Young hares are born in an advanced stage, with their eyes open and the body well furred; they can move about well, soon after birth.

14-19. MILITARY CONCERN

These animals are of military concern because they're reservoirs for tularemia, spotted fever and, to a lesser degree, plague. They also cause much economic loss from the damage they do to trees and erosion management plantings. Their burrowing may damage bunkers.

14-20. HARE AND RABBIT MANAGEMENT

Unless very large numbers are present, no control should be necessary. Trees can be protected by wrapping the trunks with wire mesh. Rabbits and hares can be excluded from small areas with a 36-inch fence buried a few inches in the ground.

Section VIII. MISCELLANEOUS ANIMALS

14-21. SKUNKS

a. Identification. Skunks are members of the weasel family and are common throughout the U.S. The striped skunk (*Mephitis mephitis*) has prominent lateral white stripes down the back in a coat of jet-black fur. It can weigh up to 8 pounds and is about 29 to 30 inches long when fully grown. The spotted skunk is smaller and more weasel-like in appearance, with white spots and short stripes in a coat of black fur.

b. On Military Reservations. Skunks can be a problem on military installations for several reasons.

- Most important is their role as reservoirs of rabies and their potential for spreading this disease to domestic animals or people. Treat any skunk with caution if it shows signs of abnormal behavior that may be associated with rabies.
- Additionally, skunks often become economic pests as a result of their damage to parade fields, gardens, golf courses and lawns while foraging for insects.
- Skunks are commonly considered to be nuisance pests due to their odor.

14-22. SKUNK MANAGEMENT

Skunks can be discouraged by cultural control methods. Sanitation can reduce harborage and food sources. Skunks may be found in debris, such as piles of wood, and they are often attracted to garbage and pet food left outdoors. Rodent control may also help alleviate skunk problems. If skunks enter buildings, exclusion is necessary. In some circumstances, skunks may be live trapped and relocated at least 10 miles away. Make sure you contact the correct authorities before relocating skunks. There are no toxic baits approved for skunk use, but burrow fumigation is an option.

14-23. OPOSSUMS

a. Identification. The opossum (*Didelphis virginiana*) is a whitish to grayish mammal with a very long and pointed face and rounded, hairless ears.

- They weigh as much as 14 pounds and average about 24 inches in length. They have a prehensile tail that's slightly less than half their total length.
- Opossums may take shelter in burrows of other animals, tree cavities, brush piles and similar cover.
- They prefer to feed on insects and carrion, but will eat fruits, grains, and vegetables.

b. On Military Reservations. On military installations, they can become a problem in garbage cans or compost piles, and they will eat pet food. Opossums have a range of 10 to 15 acres and usually live alone.

- They're most active at night and appear to roam randomly until they find a suitable home.
- When threatened, opossums usually hiss, bite, and screech; as a last resort, they may go limp, as though dead.

c. Management. Opossums will rarely require management. Sanitation is the best option. Keep pet food indoors, keep lids on garbage cans, and keep harborage to a minimum.

14-24. RACCOONS

a. Identification. The raccoon (*Procyon lotor*) has a prominent black mask over the eyes and a heavily furred, ringed tail.

- It's 2 to 3 feet long and weighs between 10 and 30 pounds.
- It has a grizzled salt-and-pepper gray-black color, and some individuals are strongly washed with yellow.
- Raccoons den in hollow trees, ground burrows, brush piles and abandoned buildings.
- They are omnivorous, eating a wide range of plant and animal food.
- Raccoons don't hibernate but may become less active during very cold weather.
- They're nocturnal and have a home range that can vary from 3 to 20 miles.

b. On Military Installations. On military installations raccoons can cause damage to homes and other buildings by tearing off shingles and boards to gain access to an attic, wall space, or chimney to set up home.

- They can also become a nuisance around gardens or garbage cans where they search for food.
- Like the skunk, the raccoon is a reservoir of rabies and should always be handled with extreme care. Even if not infected, take special caution with these animals because of their great strength.

c. Management. Exclusion, sanitation, and if necessary, live trapping are the best options for managing raccoons.

14-25. WHITE-TAILED DEER

a. On Military Installations. Deer populations (particularly white-tailed deer) in many parts of the country are rapidly increasing. Areas overpopulated by deer provide insufficient forage, so deer invade yards and gardens to find food. Deer may also be road and runway hazards.

b. Deer Management. Hunting may be used in some situations to manage the population, but in garrison this is not feasible. Professional removal services are available (Wildlife Services) on military installations. Use of contraceptives has recently been initiated in some

locations. Exclusion of deer is generally not effective.

14-26. FERAL CATS

a. On Military Installations. Feral cats are becoming an increasingly vexing problem on military installations. Many animals are lost or left when people move or simply decide they no longer want the animal. Many of these cats are not spayed or neutered, so the feral population continues to increase. Cats are primarily hazardous to wildlife, especially passerine birds.

b. Feral Cat Management. This is a very politically charged issue. There are many animal rights groups that vociferously reject euthanasia and instead support spay, neuter and release programs. The DOD position is that feral cats should be trapped and the final disposition is the responsibility of military veterinarians.

14-27. GENERAL MANAGEMENT PRECAUTIONS

Exclusion, trapping, repellents, and habitat modification are some of the management techniques used when vertebrates become a problem.

- Since the legal status of these animals can vary from state to state and in overseas areas, contact state and local wildlife agencies which can give guidance on stopping nuisance problems on the installation.
- Because of the rabies danger, always check with the installation medical authority before attempting to remove sick or dying animals.

EXERCISES, LESSON 14

REQUIREMENT. Answer the following questions by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. Moles and gophers are of concern on military reservations because they can damage _____

2. Pocket gophers are controlled best by _____

3. List two reasons fumigants are unsatisfactory in controlling gophers.

   a. _____

   b. _____

4. List two diseases for which prairie dogs serve as hosts.

   a. _____

   b. _____

5. Liberally applying naphthalene flakes or moth balls in enclosed attics is a way of repelling _____ in attics.

6. On a military reservation, ground squirrels are serious pests around airstrips and bunkers because _____
_____
_____.

7. How are hares and rabbits different from rodents? _____
_____

8. List three diseases for which hares and rabbits are the reservoir.

a. _____

b. _____

c. _____

9. The disease skunks and raccoons can spread to humans is _____.

10. Before attempting to remove sick or dying skunks, opossums, or raccoons on a military installation, check with _____
_____.

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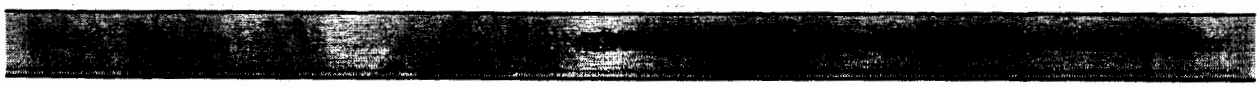


LESSON ASSIGNMENT	
LESSON 15	Biology of Termites.
LESSON ASSIGNMENT	Paragraphs 15-1 through 15-12.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to identify termites by description of damage, natural history, and physical description in accordance with Olkowski, Daar, Olkowski, *Common Sense Pest Control* and Borrer, Triplehorn, and Johnson, *An Introduction of the Study of Insects* and *AFPMB Military Pest Management Handbook*.
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the references listed, you should be able to: 1-1. Distinguish the difference between ant and termite morphology. 1-2. Identify characteristics common to all termites. 1-3. Identify the physical and biological characteristics of the following termites: ♦ Subterranean termites. ♦ Drywood termites. ♦ Dampwood termites. ♦ Powderpost termites. ♦ Formosan termites.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 15

BIOLOGY OF TERMITES

Section I. GENERAL INFORMATION

15-1. INTRODUCTION

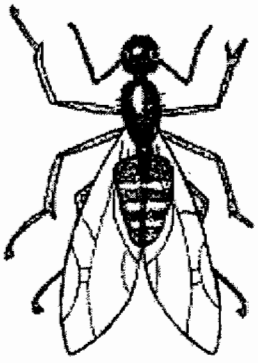
Termites are medium-sized, cellulose-eating social insects comprising the Order Isoptera. This is a relatively small group of insects, consisting of approximately 2000 species worldwide, most of them tropical. We often consider termites only as economic pests, however they are beneficial organisms as well.

- Termites may be very destructive, since they feed on and often destroy various structures or materials that people use. These include wooden portions of buildings, furniture, books, utility poles, fence posts, many fabrics, and the like.
- Termites are beneficial because they are decomposers that assist in the conversion of dead trees and other plant products into substances that can be used by plants and microorganisms.

15-2. TERMITES AND COCKROACHES

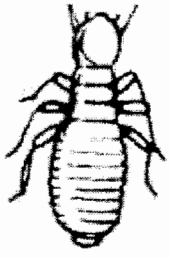
Though termites are commonly referred to as "white ants," they are not ants, nor are they closely related to ants. Ants are grouped with bees and wasps in the order Hymenoptera, whose social system has evolved independently of that of the Isoptera. Termites are most closely related to the cockroaches, both having probably evolved from a primitive cockroach like ancestor.

15-3. TERMITES vs. ANTS

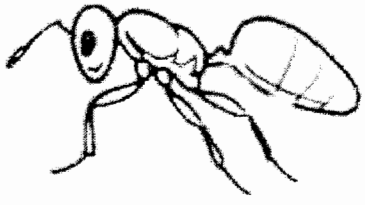


ant alate

termite alate



termite worker



ant worker

There are many important differences between termites and ants, the following descriptions are taken from Borror, Triplehorn, and Johnson, *An Introduction to the Study of Insects*.

- **Bodies**. Termites are soft-bodied and usually light-colored.
  Ants are hard-bodied and usually light to dark brown.

- **Antennae**. The antennae in termites are not elbowed as in ants.

- **Wings**. The front and hind wings of termites are nearly equal in size and are held flat over the abdomen at rest. In ants the hind wings are smaller than the fore wings and the wings at rest are usually held above the body.

  -- In termites, the wings, when shed, break along a suture, leaving only the wing base, or "scale," attached to the thorax.

- **Abdomen**. The abdomen in termites is broadly joined to the thorax.
  In ants, the abdomen is constricted at the base, forming the characteristic hymenopteran petiole, or "waist."

- **Sterile castes**. The sterile castes (workers and soldiers) in termites is made up of both sexes, and reproductives and sterile castes develop from fertilized eggs. In ants, the sterile castes are made up of females only; and all females, sterile and reproductive, develop from fertilized eggs, while the reproductive males develop from unfertilized eggs.

15-4. TERMITE COLONIES

Termite colonies contain several castes, each with specific functions. A typical colony consists of one or more pairs of reproductives, king and queen, and two nonreproductive castes known as workers and soldiers. New colonies form when reproductives swarm or fly away from overcrowded colonies, usually in the spring or fall depending on the species. After swarming, males and females pair off, seek nesting sites, discard their wings and mate.

15-5. CASTE FUNCTIONS IN THE COLONY

In the initial stages of colony formation , the reproductives feed the young and tend to the nest. As the nymphs increase in size and number, castes are formed. The workers maintain and feed the colony, damaging wood while tunneling for food. Soldiers, with their large head capsules and strong mandibles, protect the colony but do not feed on wood. Workers feed soldiers.

15-6. SOURCES OF TERMITE FOOD

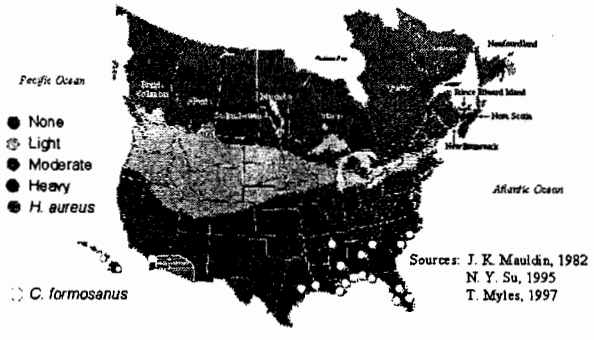
Termites feed on cellulose from wood or wood products. Cellulose digestion is aided by protozoa living in the termite's digestive tract. The workers provide food for the young and other castes through regurgitation and excretion. This also provides immature termites with digestive protozoa. Dead and dying members of the colony are also consumed. Due to their soft bodies, termites require a high humidity environment or they may desiccate. As with other insects, termites are only active when temperatures are above 50-60°F. Foraging workers may construct tunnels to shield against predators and unfavorable environments.

Section II. U.S. TERMITES

15-7. TYPES

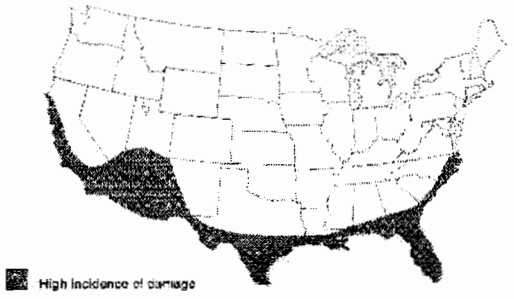
There are five major groups of termite pests in the United States: subterranean, drywood, dampwood, powderpost, and Formosan. Basic characteristics are compared on page 15-5. Subterranean termites are found in every state and in Canada and are responsible for 95% of termite-related damage.

Subterranean Termite Zones of North America



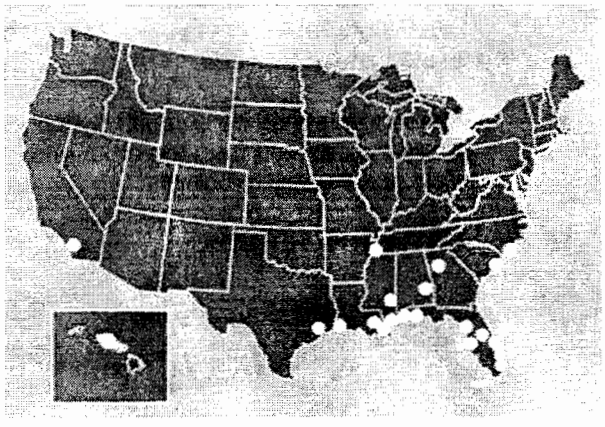
Drywood termites have a more localized distribution, but are currently the most costly to treat.

Figure 1
Drywood Termite Damage



Source: U.S. Dept. of Agriculture, Forest Service. Undated. You can protect your home from termites. Washington, D.C. U.S. Government Printing Office.

Formosan termites are expanding their range, but are still mostly localized in Hawaii and the Gulf Coast states.

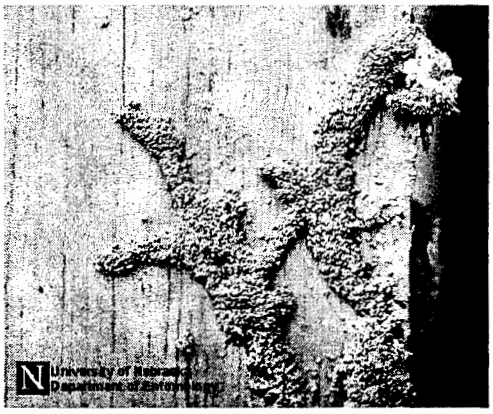


15-8. SUBTERRANEAN TERMITES

These termites must maintain regular contact with moisture, which in most cases, means they must maintain contact with the soil. Subterranean termites are the most important termite pests in most of the United States.

- The requirement to remain in contact with moisture (soil) limits their ability to attack only wooden structures within reach of the moisture source.

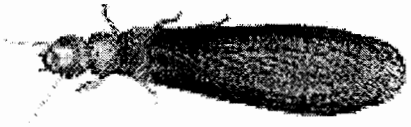
- They will construct distinctive earthen tubes to bridge between the soil and the susceptible wood The passageways protect them from predators and desiccation as they travel between the soil and the wood.



- The presence of these tubes is a important visible clue to the presence of subterranean termites.

- These tubes may be surprisingly long. They may extend from the ground to the attic of a 2-story building.

15-9. DRYWOOD TERMITES



Drywood termites do not require much moisture and can attack a structure at points far removed from the soil.

- In their natural habitat, they are found in dead trees.

- They also infest telephone poles, piled lumber, and posts.

- Drywood termites enter wood through cracks and crevices and excavate a gallery.

- They then plug the entrance with partially chewed wood and a cement-like secretion.

- They drill small, round "kickholes" along the outer gallery wall for expulsion of waste.

- Piles of tiny, sawdust-like pellets are a distinctive sign of drywood termites. These pellets are indented and appear 6-sided.

15-10. DAMPWOOD TERMITES

Dampwood termites are found primarily in wet, decaying wood, although they can extend there feeding into dry sound wood. Once the water problem is corrected, the rotted wood replaced, and the termites eliminated, the problem is usually rectified. Those of greatest importance are found in the Pacific Coast states.

15-11. POWDERPOST TERMITES

These are primarily subtropical termites of Florida, Louisiana, southern California and Hawaii.

- They are occasionally transported in household goods to other locations.

- They attack furniture, books, stationery, dry goods, and building timbers and frequently do a great deal of damage.

15-12. FORMOSAN TERMITES

Formosan termites are natives of China and Taiwan and are serious pests. They are actually a type of subterranean termite. In 1965, they were discovered in Houston, TX. Since then, they have become serious pests in many areas. Formosan termites are the most important termite pests in Hawaii and may be becoming so in Louisiana and other Gulf Coast States.

- These termites are considered a serious threat in tropical and subtropical regions because of their voracious feeding habits.
- They attack a greater variety of materials, build more extensive tubes and galleries than other subterranean termite species and they are difficult to control.
- Formosan termites may produce satellite colonies above ground inside buildings. These colonies cannot be controlled with soil treatments and often require fumigation of the entire building.

TERMITE	DISTRIBUTION	HABITAT	BEHAVIOR	APPEARANCE
subterranean termite (*Reticulitermes* spp.)	throughout the United States	ground-dwelling in moist sites	builds earthen tubes; does not form fecal pellets	workers and soldiers 6mm long; winged forms 13 mm long
drywood termite (*Incisitermes* spp.)	Southern and coastal areas	dry sites	forms oval, six-side fecal pellets; expels fecal pellets in sawdust-like piles from "kickhole" exits in galleries	larger than subterranean but smaller than dampwoods; winged forms and soldiers up to 13 mm long
dampwood termite (*Zootermopsis* spp.)	western United States and lower California	damp, decaying wood	produces large, oval fecal pellets; forms only reproductives and soldiers; no workers	largest termite in U.S.; winged forms 25 mm long, with wings twice the length of the body
powderpost termite (*Cryptotermes* spp.)	Southern and subtropical areas;	dry wood, furniture, woodwork, floors	forms small fecal pellets	small; winged forms 11 mm long
Formosan termite (Coptotermes formosanus)	Along Gulf and souther Atlantic coasts, Florida, Hawaii	ground dwelling but also builds satellite colonies above ground in structural lumber, living plants,	builds earthen tubes; swarms on warm evenings after rain	soldiers have oval head with prominent horn-like gland; winged forms pale yellow brown with wings 13 mm long.

Basic characteristics of termites.

EXERCISES, LESSON 15

REQUIREMENT. Answer the following questions by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. Termites are both destructive and beneficial.

   a. Destructively, termites _____
   _____
   _____

   b. Beneficially, termites _____
   _____
   _____

2. Identify differences between termites and ants.

Antennae. Termited antennae are _____.
Ant antennae are _____.

Wings. Termite wings are held _____
_____.

Ant wings are usually held _____
_____.

3. Why and when do new termite colonies form? _____
   _____
   _____
   _____
   _____
   _____

4. What are the jobs of termites in their colony?

   a. Workers _____
   _____

   b. Soldiers _____
   _____

5. List three reasons termite workers construct tunnels in wood.

   a. _____

   b. _____

   c. _____

6. What must the temperature be for termites to be active? _____

7. _____ termites, found throughout the U.S., build earthen tubes. The soldiers and workers are 6 millimeters long, and the winged forms are 13 millimeters long.

8. The _____ termite, found in the western U.S. and lower California, is the largest termite in the U.S. The winged forms are 25 millimeters long with wings twice the length of the body.

9. The _____ termite, found along the Gulf and Hawaii, lives in structural lumber and living plants, builds earthen tubes, and swarms evenings after rains.

10. Identify the termites with these characteristics:

- These termites infest telephone poles, piles limber, and posts.
- They enter wood through cracks and crevices and excavate a gallery.
- They drill small, round "kickholes" along the outer gallery wall for expulsion of waste.
- Piles of sawdust-like pellets indicate their presence.

They are _____ termites.

LESSON ASSIGNMENT

LESSON 16	Control of Termites.
LESSON ASSIGNMENT	Paragraphs 16-1 through 16-12.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to employ integrated pet management principles against termites in accordance with AFPMB *Military Pest Management Handbook.*, and Olkowski, *Common Sense Pest Control.*
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the references listed, you should be able to: 16-1. Identify the three principles of good termite management. 16-2. Identify the building construction practices which can lead to easy infestation by termites. 16-3. Identify measures which can prevent or control termite infestation in existing structures. 16-4. Identify inspection procedures which should be done when inspecting a house for subterranean termites. 16-5. Select appropriate control measures for termite infestations.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 16

CONTROL OF TERMITES

Section I. DAMAGE BY TERMITES

16-1. INTRODUCTION

Termites are the most destructive insect pests at military activities. They may so severely damage a building as to be responsible for its condemnation and replacement.

- They eat wood and other cellulose products such as paper, cardboard and fiberboard, and will destroy structural timbers, pallets, crates, boxes, tool handles, furniture, books, and other wood products.
- Also, in their search for food, they will damage many materials that they don't normally eat.

- In tunneling through the ground, subterranean termites will penetrate lead-covered and plastic covered electrical cable. In doing so, they can cause shorts in electrical systems.

- Termites may live for years in buried tree stumps or form lumber beneath concrete buildings.

  -- Then, by penetrating hairline cracks in floors and walls as well as expansion joints, they may suddenly erupt in search of edible materials such as may be found in interior door frames and rarely-moved furniture such as file cabinets and book cases.

- In attacking packaging and crating in storage areas, they will seriously damage stored items such as nylon parachutes and woolen clothing.

16-2. DAMAGE PATTERN

Termite damage to buildings follows predictable patterns. If permitted to continue, the damage can become extensive. Structures may be subject to attack depending on the design, building materials used, quality of workmanship, and certain environmental factors.

a. Predictability of Termite Attacks. Termite attacks generally follow a predicable pattern. This predictability of the attack patterns permits both understanding and execution of preventive inspection and control programs.

b. Subterranean Termite Attacks. In their blind probing for new sources of food, subterranean termites construct exploratory tunnels through the soil.

- These tunnels emerge above the ground level, and are then usually cemented securely to solid objects such as foundation walls and piers or pipes.

- These tubes of earth and other materials will, when protected, continue upward until food is found, often reaching heights of several feet.

c. Termite Search for Entry. If solid objects block their path, termites will continue probing until they have found or created a passage.

- Expansion joint fillers may be penetrated.
- Natural cracks in foundation walls may be utilized.

- As the spaces between bricks or building blocks are rarely completely filled, these areas may be used.

- Hollow tile foundations can provide a nearly perfect approach to structural wood as the termite tubes are well protected and are not detected during inspections.

- Once gaining entry to the wood of a building, the termites may carry on their destruction for several years before they are found.

- The use of termite shields will, if properly installed and maintained, force the termites to extend their tubes out over the surface of the shields and will so facilitate inspections.

d. Types of Buildings.

- In buildings comprised primarily of concrete and masonry, damage may be limited to such wooden items as doors and window frames, base boards, and insulating materials composed of wood fibers.

- In masonry and concrete buildings with wooden decks, the damage may be first evident in door or window frames, or baseboards, but more extensive hidden damage to studs, sheathing, and sole plates may exist.

- In wooden frame buildings the pattern will vary depending on the type of construction and environmental factors, but may be of all these types.

16-3. EXTENSIVE INFESTATIONS

a. Damage in a New Building. Though it is unusual, a new building may be severely damaged during its first few years. This can happen when wood debris, usually tree stumps and roots containing large, active colonies, is left in the soil at the building site. Under such conditions, the extended pattern of damage will be the same as that found in older building with well-established colonies, the control of which has been neglected.

b. Damage Above the First Floor. The emergence of termites at a point much above the first floor level in a frame structure would normally indicate a large colony and considerable damage. An emergence of subterranean termites may occur in the attic of a two-story building. Subterranean termite tubes have been found at an elevation 62 feet above the ground level in a military building.

Section II. THREE PARTS OF A TERMITE CONTROL PROGRAM

16-4. THREE PARTS

An effective and economically managed program of termite control will always include the three principal phases of: inspection, preventive control, and such corrective control as may be required.

16-5. INSPECTION

a. Frequency. In regions of high termite activity, all structures built wholly or partly of wood should be inspected annually for active termite infestations regardless of preventive measures employed in construction. Attention must also be given to those conditions conducive to future termite attack.

- Under some conditions inspections should be made more or less frequently than once per year. Contact your MajorCommand Entomology Consultant for inspection frequency at your installation.
- The subterranean nests of termite colonies, or points of entry into buildings, can often be located quickly if the emergence is observed.
- Pest control supervisors should give prompt attention to all complaints, such as those concerning "flying ants," which could indicate a termite emergence.
  - -- All information available at the time of the inspection should be recorded on the DD Form 1070, Termite and Wood Decay Inspection Form, used for recording the scheduled semi-annual inspections.

b. Purpose. The purpose of the semiannual inspection is twofold; and it involves the on-the-site planning of control procedures as well as the detection of active or potential infestations. Because of this, the inspections of structures should be made by personnel trained in the selection and application of the proper control techniques as well as in the determination of the need for control.

16-6. PREVENTIVE CONTROL

The best time to provide protection from subterranean termites is during the planning and construction of a building. Many common design and construction practices are favorable for infestation. Some preventive control measures can be applied after construction and during the use of the buildings.

a. Construction. Military buildings should be planned and constructed to provide protection against termites. Recommendations regarding design and construction and the use of wood preservatives should be followed without deviation regardless of the urgency to complete construction by a specified date.

- Some common errors of design and construction are:
  - -- Burial of stumps, logs, boards, stakes, form lumber and wood scraps beneath buildings or next to the foundations.

-- Improper grading and drainage; insufficient air circulation and cross-ventilation.

-- Failure to use chemically preserved wood.

b. Site Sanitation. All surplus wood including stumps, tree roots, logs and other wood debris should be removed from the building site before construction work is started. All form lumber, grade stakes, and wood scraps should be removed by the time construction work has been completed.

c. Foundation Construction. It is important that building foundations be impervious to subterranean termites and that woodwork resting on the foundation be protected against attack. Foundation types may be rated by their relative resistance to penetration.

♦ Poured concrete, reinforced to prevent cracks, with the expansion joints properly filled.

♦ Masonry walls capped with a minimum of 4 inches of reinforced concrete or its equivalent.

♦ Hollow blocks with all of the top rows and joints between blocks filled with concrete.

♦ Wood posts, piers, steps, or braces pressure treated with an approved chemical preservative and capped, when recommended, with metal termite shields to prevent the insects from gaining hidden access to the buildings or other structures.

d. Ventilation and Drainage. It is necessary to provide adequate ventilation and drainage to prevent termite attack.

♦ The number and size of openings should be determined by the soil moisture, air movements, and humidity.

♦ Areas beneath buildings should be well drained.

♦ The soil adjacent to foundation walls should be graded to permit the drainage of surface water away from the buildings.

e. Clearance Beneath Buildings. To facilitate periodic inspections for subterranean termites, adequate crawl space should be provided beneath buildings. The minimum clearance for effective inspection is 18 inches from ground to the bottom of lowest joist, beam, or girder.

f. Skirting. When skirting is used, a clearance of 3 to 6 inches between it and the ground is needed. If this space is closed in winter, it should be reopened early each spring.

g. Miscellaneous Appendages.

♦ All miscellaneous building appendages including porches, steps, terraces, platforms, and fire escape ladders should be installed with an unbridged clearance or effective barrier so as to prevent entry of termites into buildings.

♦ All wood used in contact with the soil should be pressure treated with approved wood preservatives.

♦ Only treated wood should be used for construction timbers placed on concrete or masonry foundations.

♦ Pipes and conduits often provide entrance points for termites.

-- Plumbing, electrical conduits, and other piping should be installed clear of the ground and should not be supported by wood braces or other appendages that touch the ground.

-- At the point where piping enters the floor or wall from below the foundation, a funnel type shield caulked with coal-tar mastic provides an effective barrier.

h. Chemical Soil Barriers. Residual insecticides may be added to the soil. When properly applied, they will provide long-lasting barriers of poisoned soil adjacent to foundation walls and piers and under concrete slabs. Always read the label prior to applying any pesticide to ensure that it is labeled for the pest, the correct concentration, and the prescribed manner of application.

i. Wood Preservatives. Lumber and other forest products that are exposed to excessive moisture, to fungi, and to wood destroying insects such as termites should be treated with wood preservatives to prolong their useful life.

- The type of treatment and the preservatives to be applied will depend upon the type and severity of exposure and upon the desired life of the material treated.
  - -- Surface treatments, as well as dip or soak treatments, which provide shallow penetration will protect wood against dry-wood termites.
  - -- However, the deeper penetration provided by pressure treatment is required for protection against subterranean termites.
- Only the wood actually treated is protected. Termites will "bridge over" treated wood with their shelter tubes just as they will bypass other inedible structural materials.

j. Screening. As a deterrent to attack by dry-wood termites, 18x18 mesh, non-corrodible screen may be used to cover all points of entry such as windows, doorway, ventilators, and other opening. Particular attention should be given to screening louvers, eaves, or apron vents, and field strips supporting tiles.

k. Exterior Surfaces. Further prevention of attack by dry-wood termites can be obtained by maintaining smooth exterior surfaces on buildings. All exterior cracks, grooves and joints should be well filled before painting. A good coat of paint, with careful application at points of vulnerability, will aid in warding off attack.

16-7. CORRECTIVE MEASURES

No termite control program is complete unless the conditions that favor termite survival are modified. To the extent that the termite problem is associated with moisture or wood in contact with soil, these conditions must be corrected. Then other measures may be implemented as the situation warrants.

16-8. CORRECTIVE MEASURES -- CULTURAL CONTROL

a. Reducing the Moisture Level of the Wood. Any exterior feature that leaks moisture should be repaired. The investment in installing, fixing, or relocating gutters, siding, roofing, vents, drains, down spouts and vapor barriers will pay for itself in long-term protection against organisms that attack wood.

b. Eliminating Direct Contact between Wood and Soil. Ideally, wood should be at least 8 inches above the soil. Wood in contact with the soil must be replaced with concrete.

c. Removal of Tree Stumps and Wood Debris. Decaying stumps, construction debris and wood scraps near the house can be a source of termite infestation. The closer to the house they are, the greater the hazard. Wood stumps or debris within 10 feet of foundations and/or portions of a house with a history of termites should be removed.

16-9 CORRECTIVE MEASURES -- MECHANICAL CONTROL

a. Installing Termite Shields. Metal termite shields composed of sheet-metal strips bent into an L shape along one edge prevent hidden termite entry through masonry walls. If properly constructed and maintained, the shields force termites to build their tubes over the shield in the open where the tubes can be spotted and destroyed. It is a common misconception that these shields are termite-proof, but if the tubes are not destroyed, the termites will eventually cross the gap.

b. Non-chemical Soil Barriers. The use of basaltic sands beneath foundations can prevent attacks on buildings by subterranean termites, including Formosan termites. Non-chemical physical barriers have remained effective for more than eight years against Formosan termites on Midway Island. Sand particles must measure 1.8 to 2.5mm, and the sand layer must be at least four inches thick. The strategy is to produce a sand layer made of sand particles too large for termites to dislodge, but having spaces too small for termites to penetrate.

c. Screen Caps. The use of stainless steel screens as barriers to termites has been used successfully in Australia and Hawaii. This control method differs from screening discussed earlier in that it prevents attack by foraging termites. The screen mesh, which must be 30 mesh or greater, is rolled out as a capping barrier beneath the building foundation. One difficulty with this method is sealing the screen at points where electrical conduits and pipes penetrate the foundation.

16-10. CORRECTIVE MEASURES -- PHYSICAL CONTROL

a. Physical Controls for Subterranean Termites.

(1) Digging out colonies. Very small infestations, such as those adjacent to buried wood scraps in crawl spaces, can often be dug out. Even if all the termites are not removed the nest is opened up to natural enemies such as ants. Remove any pieces of wood or remains of termite tubes you find. Regularly inspect the site to make sure the colony has been destroyed.

(2) Breaking Open Termite Tubes. The breaking open and removal of the highly visible tubes effectively cuts off the connections between the colony and the structure. Once these tubes are opened, ant enemies can enter the colony and kill the termites.

b. Physical Controls for Drywood Termites.

(1) Electricity. The use of electricity to kill drywood termites is a recent development.

- Pulses of electricity are shot into the wood at low energy (90 watts), high voltage (90,000 volts) and high frequency (100kHz), killing the insects in their galleries.
- The pulse kills some termites immediately, others take weeks to die, but they all die eventually.
- Exactly how this happens and why the electricity causes termite death remain unclear.

(2) Heat Treatment. Another technology uses heat to kill drywood and powderpost termites as well as other pests such as cockroaches, ants, fleas, and wood-boring beetles. Heat technology shows the greatest promise of any current alternative tool for displacing chemical fumigation for drywood termites.

- The heat-treatment method was developed by scientists Charles Forbes and Walter Ebelingg, who demonstrated that insects can be killed by raising the temperature to 120°F (49°C) or more.
- Special equipment composed of a heating unit, blowers and ducts carriers heat to the locations in the structure where the pests are causing damage.

16-11. CORRECTIVE MEASURES – CHEMICAL CONTROL

a. Chemical Baits. EPA-approved baits are available for the control of subterranean termites. All of these baiting systems have two elements. The first consists of continuous surveillance for the presence of termite colonies around the perimeter of buildings. The second element is application of a control agent when termite activity is detected. Both the surveillance and control baits consist of stakes made of wood product. The control agent is either a toxic agent or an insect growth regulator (IGR). Surveillance stations are monitored on a predetermined schedule. When termite activity is detected, surveillance stakes are replaced with stakes impregnated with the control agent. Foraging termites carry the treated material to the colony that is destroyed. This control strategy differs from traditional soil treatments by destroying termite colonies instead of creating chemical barriers to prevent invasion of structures.

b. Chemical Control. Because in this case the control is applied to existing structures, some different techniques are used for the application of chemicals.

- Though insecticides applied to soils may kill existing colonies, the creation of a barrier of impenetrable soil is still the aim of soil poisoning.

- But because of the combination of certain types of structures and soils and of the labor costs involved, limited "spot treatment" of the most vulnerable areas may be justified in some cases.

- Because of the great variations in soil types and in termite species, limited spot treatment should be considered only as recommended by the command entomologist.

(1) Treatment Under Concrete Slab. Soil beneath a concrete slab may be treated either from above the slab or from outside the building.

- Pressure Treating. Holes are drilled through the slab on 12 to 18 inch centers 6 to 8 inches from cracks and expansion joints. The insecticide is pumped through these holes to provide quick even distribution. A plumber's test plug or similar device with an expansible rubber ring is used to seal the hole and prevent back flow of the emulsion under pressure.

- Rodding. Holes are drilled through the foundation wall beneath the slab, and long, perforated pipe, pointed at the end, is driven between the slab and the soil. The insecticide is then pumped through the rod, under pressure, as the rod is withdrawn.

(2) Drywood Termite Control. Control of existing colonies of drywood termites by means other than removal of infested wood requires the application of toxic chemicals to the termites in the wood. This maybe accomplished by injection of dust; injection of liquids; surface application of penetrating chemicals; or fumigation.

- Dusts. Insecticidal dusts may be blown into holes punched or drilled into the termite gallery. Only very small quantities are needed. For example, the desiccant silica aerogel is registered for the control of drywood termites.

- Liquids. Insecticidal liquids may be squirted through holes into termite nests. Oil formulations that stain or prevent later painting should be avoided.

- Surface treatment. If no paint film is present to block penetration, surface treatment can be effective. Grease or emulsion formulations of pentachlorophenol will penetrate satisfactorily, but can be fortified with insecticides.

- Fumigation. Structural fumigation with methyl bromide will kill all dry-wood termites in the structure. However, it is expensive and hazardous, and provides no residual effect to prevent future infestations.

6-12. NEW DEVELOPMENTS

The termite control industry is one of the most rapidly changing in all of pest management. Novel control strategies are under development, and new bio-safe chemicals are being registered. The potential for extensive economic losses, high cost for termiticide treatments, and EPA restrictions on the use of long-term residual pesticides have all contributed to this rapid technological advance. New strategies are always under investigation and these include the following.

a. Non-repellent insecticides. Many traditional pesticides used in termite treatment programs have a repellent action. While this may prevent insects from penetrating a chemical barrier, it is also subject to failure it there are gaps in the barrier. New chemicals do not repel termites and may be more effective in that insects will readily enter treated areas and become exposed to the toxins.

b. Trap-Treat-Release. Termites are trapped and coated with slow-acting insecticides or IGRs. These treated termites are released back into the environment to pass the toxins to their nestmates by social grooming and food sharing.

c. Resistant Building Materials. Research is also underway to develop more resistant building materials.

EXERCISES, LESSON 16

REQUIREMENT. Answer the following questions by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. List the three principles of good termite management.

   a. _____

   b. _____

   c. _____

2. A new building may sustain termite damage if _____
   _____

3. What does termite damage above the first floor of a building indicate? _____
   _____
   _____

4. Failure to use chemically preserved wood in a new building can lead to _____
   _____

5. Masonry walls of a new building should be capped with _____ or its equivalent to prevent termite intrusion.

6. The minimum crawl space clearance beneath buildings should be ____ inches from the ground to the bottom of the lowest joint, beam, or girder.

7. List two methods of physical control for drywood termites.

   a. _____

   b. _____

8. Two methods of mechanical control of subterranean termites are:

   a. _____

   b. _____

9. List three disadvantages of structural fumigation with methyl bromide as termite corrective control strategy.

   a. _____

   b. _____

   c. _____

10. List the steps in the procedure of treating termites under a concrete slab.

- _____
  _____
- _____
  _____
- _____
  _____

	LESSON ASSIGNMENT
LESSON 17	Wood Destroying Organisms.
LESSON ASSIGNMENT	Paragraphs 17-1 through 17-15.
TERMINAL LEARNING OBJECTIVE	Information gained in this lesson should enable you to identify damage caused by wood destroying organisms and employ IPM IAW AFPMB *Military Pest Management Handbook*.
SPECIFIC LESSON OBJECTIVES	After completing this lesson IAW the reference listed, you should be able to: 1-1. Identify the insects that cause damage to wood. 1-2. Identify the type of wood damage caused by fungi. 1-3. Identify the appropriate preventive and corrective control measures for wood destroying organisms.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

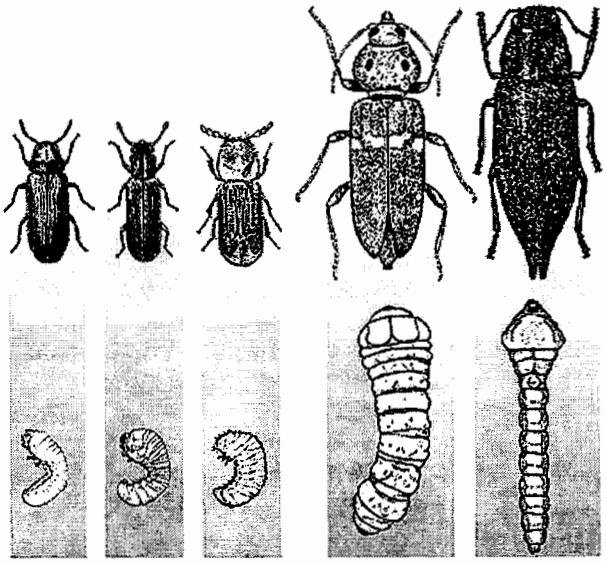
LESSON 17

WOOD DESTROYING ORGANISMS

Section I. WOOD DESTROYING INSECTS

17-1. INTRODUCTION

While termites are widely known for their damage to homes and other wooden structures, there are lesser-known wood attacking insects which also cause millions of dollars worth of damage structures and other items. The following picture shows larvae and adults of several common wood destroying beetles. From left to right the families are: Lyctidae, Bostrichidae, Anobiidae, Cerambycidae, and Buprestidae.



17-2. POWDER POST BEETLES

Powder post beetles are so named because they can reduce wood to finely powdered frass. They belong to four families: Lyctidae, the lyctus powder post beetles; Bostrichidae, the large powder post beetles; Anobiidae, the deathwatch post beetles or anobiid powder post beetles; and Ptinidae, the spider beetles.

a. Description. Larval stages of these beetles are very similar, so accurate identification is difficult. Generally, they're white or yellow, soft bodied and hairy, with well-developed, five jointed legs. Larval mines in wood are tightly packed with frass.

b. Activity in Wood. Most powder post beetles can work in dry, well-seasoned wood, damaging finished products such as tool handles and gun stocks, joists, beams, floorings, and high grade lumber in storage.

- Powder post borers may continue to work in the same wood until nothing is left but a thin outer shell filled with powdery frass.
- Beetle activity is often revealed by flecks of powdery dust beneath infested timbers.
- The larva of a single powder post borer can cause considerable damage, but most species don't deposit eggs on wood after is has been seasoned; this limits the danger of reinfestation and overall damage.

c. Family Lyctidae. Lyctid beetles are small (1/12 to 1/5 inch long), slender, slightly flattened or oval and dark brown to black. They annually destroy thousands of board feet of seasoned lumber and large supplies of wood products, such as tool handles and gun stocks. They readily attack the sapwood of large pored hardwoods. Ash, hickory, pecan, oak, and walnut are particularly susceptible to attack. Females lay eggs in large pores of the wood. Wood with a moisture content of 15% or less is most susceptible to attack.

- *Lyctus planicollis* and *Lyctus parallelopipedus* are the two most destructive species of the genus *Lyctus* in the eastern half of the United States.
- *Lyctus parallelopipedus* can complete its life cycle in three months in extreme southern areas, while other species may take 9 to 12 months.

d. Family Bostrichidae. The larger powder post beetles belong to this family.

- These beetles are reddish, brown, or black, 1/8 to 3/4 inch long, and cylindrical. The heads of both anobiids and bostrichids are directed downward and are covered by a hood-like pronotum.
- Some species infest hardwoods; others attack softwoods. Many can be imported in lumber or in veneer plywood and furniture where even destruction on a limited scale can cause considerable financial loss.
- The red-shouldered shothole borer, *Xylobiops basilaris*, is probably the most common bostrichid of the eastern U.S. It attacks practically all freshly cut and partially seasoned hardwood, and frequently damages furniture.
- *Polycaon stouti* is an important powder post beetle in California, attacking willow, hickory, and many other woods and furniture. It's especially injurious to softwoods, such as basswood, which often becomes infested while in storage before it's used for furniture.

e. Family Anobiidae. Anobiid powder post beetles are small, usually 1/8 to 1/4 inch long. This family includes a number of destructive species that may be selective or attack both softwoods and hardwoods; larvae can cause considerable damage.

- The common furniture beetle, *Anobium punctuatum*, is a small, elongated, subcylindrical, brown beetle about 1/8 inch long. Its larvae often damages pine flooring, joists, and furniture.

- The death-watch beetle, *Xestobium rufovillosum*, is an oblong, rather stout beetle, 1/4 inch long, dark brown, and spotted with patches of yellowish hairs. It's occasionally found in the woodwork of moist cellars in New England states.

f. Family Ptinidae. The ptinids are a small group of diminutive beetles, none more than 1/5th inch long. Most are clothed in short hairs and are dark brown or black. Ptinids are characterized by long legs that give them a "spider-like" appearance. At least two species may attack wood.

- The most widely known beetle in this family is the brown spider beetle, *Ptinus brunneus*. This beetle may occasionally damage pine boards in old buildings.

- The white-marked spider beetle, *Ptinus fur*, is a small, brown, oval, long-legged beetle, about 1/8 inch long, and resembles a spider. It's often found in buildings and warehouses. It generally feeds on dried vegetable or animal matter, but it has been found in pine and oak woodwork.

17-3. ROUNDHEADED WOOD BORERS

Roundheaded wood borers belong to the family Cerambycidae. Larvae are called round-headed borers; adults are called long-horned beetles. These beetles feed mainly on dry wood. They play an important role in nature by destroying dead trees permitting new growth.

a. Identification. In structural woods, they can be distinguished from all other wood-boring beetles by a few prominent characteristics. The larvae are large (1 inch or more long), fleshy, thin-skinned, white or yellowish, and more or less cylindrical. They may taper posteriorly, but this tapering is very gradual. Larvae may or may not have legs.

b. Oviposition/Destructiveness. Within this family, the oviposition habits of a species are one indicator of its specific destructiveness.

- Some species eggs are laid in deep crevices of bark; others are deposited within the bark; still others, like the eggs of the old house borer, are deposited in season checks of exposed wood.

- These beetles may oviposit where trees are felled (certain borers attacking only recently cut wood); use of infested wood for construction can result in serious damage later.

- Borers that attack only freshly cut wood normally develop in a year or two. But if infested wood is stored or used under dry conditions, the larval period may be extended several years, occasionally up to 12 years.

c. Old House Borer (*Hylotrupes bajulus*). This beetle deposits its eggs in the season checks and crevices of wood, and can infest seasoned wood years after it's used for construction. It's commonly found in framing studs, roofs and subflooring. It only attacks the sapwood of conifers. This European insect is now well established in the U.S. and is becoming more abundant and destructive each year. In Europe and South Africa, it's a major pest of coniferous wood.

(1) Identification. The adult borer is an elongated, dark brown beetle, about 1/2 to 3/4 inch long. The thorax is rounded, with several small tubercles at the sides and a black polished line and spots on the upper surface. The wing covers have whitish spots that form two irregular bands across their middle. Larvae are thin-skinned, the head is wider than it is long, the tips of the mandibles are rounded, and there are three ocelli (simple eyes) on each side of the head. The prothorax is smooth and shining and legs are present.

(2) Life cycle. Larval mines are loosely filled with frass, which is composed of tiny pellets and fine powdery material. The old house borer completes its life cycle in five to seven years in the north and usually three to five years in the south.

d. Flat Oak Borer (*Smodicum cucujiforme*).

(1) Identification. This is a small, elongate, dorso-ventrally flattened, shiny beetle with a dull yellow color; it's 1/3 to 2/5 inch long. The species occurs throughout the eastern U.S. Larvae excavate long meandering galleries in the dry heartwood of oak and hickory, packing them tightly with fine granular frass. The pupal cell is near the surface of the wood and is merely an enlargement of the gallery. Stored lumber is frequently infested and larva feed in it until the wood is thoroughly riddled.

(2) Life cycle. The life cycle may be completed in one year in green logs and under forest conditions but lumber drying activities may extend larval development to several years.

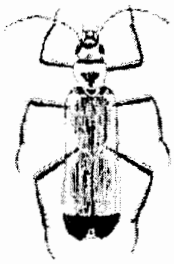
e. Ivory Marked Beetle (*Eburia quadrigeminata*).

(1) Identification. This beetle is elongate, one-half to one inch long, and pale yellow. It has two pairs of ivory white spots on each wing cover, the first pair longitudinal and near the base, the second just behind the middle of the wing. The larvae are robust and sedge-shaped, tapering posteriorly, with a tough, shining integument (outer covering) sparsely covered with golden hairs. The legs are distinct, long and four-jointed.

(2) Damage. The heartwood of hardwoods is seriously damaged by the large, contorted larval mines, which are tightly packed with frass. Mature trees with scars or "catfaces" which give larvae access to hardwood are often badly damaged. Adults may also attack lumber undergoing seasoning. Oak, hickory, ash, chestnut, maple, and cypress are susceptible to infestation. In buildings, beetles may emerge from flooring or furniture, years after the infested wood is used.

f. Other Roundheaded Borers. Many other cerambycids attack wood under a variety of conditions. They're occasionally found in buildings or stored lumber where, in rare cases, they may do considerable damage. Because their attacks on clean seasoned wood are rare, they have little economic importance.

17-4. WHARF BORERS



The Wharf borer (*Nacerdes melanura*) is economically important because of its damage to pilings and decks under wharves, pilings under buildings near the water, and boardwalks along the seashore. It is occasionally a pest of utility poles. This insect is found in very moist wood, and wood rotting fungi are often associated with its work.

a. Identification. Adults are 1/2 inch long and resemble the long-horned beetle, however it is in the family Oedemeridae. The color varies from yellow to light brown with black tips on the wing covers, legs and body underside. The larva is about an inch long, narrow and cylindrical and has a wart-like swelling on its upper side between the thorax and abdomen. The wharf borer is common on the Pacific and Atlantic coasts and along the Great Lakes.

b. Treatment. The only treatment is to replace infested wood. Infestations usually can be avoided if all wood used in pilings and wharves is pressure-treated with an approved pesticide before it's used.

17-5. FLATHEADED WOOD BORERS (METALLIC WOOD BORERS)

Flatheaded borers are in the family Buprestidae. They range in size from 6-34 mm in length. They are flattened, and may be strikingly marked; some are metallic. They are usually found in new structures when they emerge from wood and are attracted to lights or windows. Most will not re-infest a structure, in which case, replacement of damaged wood is the only treatment necessary. Sometimes these beetles enter structures in firewood.

17-6. MISCELLANEOUS WOOD-DESTROYING BEETLES

Other wood destroying beetles sometimes encountered at military installations include broad-nosed bark beetles (family Curculionidae), pinhole borers such as ambrosia beetles (family Scolytidae), and timber worms (family Brentidae).

- The larvae of most species of bark beetles cut meandering galleries across the grain of seasoned coniferous wood and pack them tightly with frass.
- Adult bark weevils are small, oblong or elongate, black or brown, with or without eyes, and the beak is often short and broad at the tip.
- For example, *Hexathrum ulkei* sometimes destroys coniferous woodwork in old buildings and cypress pilings in the eastern U.S.
- *Tomolips querciocola* may damage buildings containing seasoned coniferous wood such pine flooring and cypress paneling.
- Ambrosia beetles and timber worms usually attack living or recently felled trees and need moist wood favorable to fungal growth.
  - -- The best protection against ambrosia beetles is to install only well seasoned lumber, and keep it dry after construction.

17-7 PREVENTIVE MEASURES

It is crucial to use preventive measures where wood boring beetles may cause damage.

- Lumber, wood furniture, antiques, etc. should all be inspected for damage prior to being used or brought into a building.
- Use kiln- or air-dried lumber in all construction projects. This process kills many beetles.
- Cover susceptible and exposed surfaces with paint, varnish, or other sealant wood coats.
- Reduce moisture levels in buildings.
- Store firewood and lumber away from susceptible structures. Debarking firewood is a good prevention against many species that live part of their life cycle in bark.

17-8. DETECTION AND SURVEILLANCE

Most wood boring beetles can be identified with a combination of the following damage characteristics.

- Size and shape of exit holes
- Size, shape, and contours of tunnels (engraving patterns)
- Size and shape of frass
- Damage in hard- or softwood
- Damage in old or new wood

Discovery of wood boring beetle damage does not necessarily mean the infestation is active. Some wood borers do not re-infest wood and once they emerge, no further damage will occur. Some beetles that do not re-infest wood include most cerambycid beetles (except old house borer), ambrosia beetles (family Scolytidae), and flatheaded borers (family Buprestidae). It is important to correctly identify the pest (whether it is a re-infesting species or not) to avoid conducting unnecessary corrective measures.

17-9. CORRECTIVE MEASURES

a. Cultural Control. Many wood boring beetles can be controlled by altering environmental conditions favorable to the beetles. Most important of these is moisture content in wood. Many beetles infest moist wood. For example, old house borers typically infest moist wood that has already been attacked by fungi.

b. Mechanical Control. Damaged wood should be replaced as soon as it is detected. Many species do not re-infest wood after they emerge, so this is an effective control for this type of pest. If the wood is repaired instead of replaced, it should be painted or coated to prevent re-infestation.

c. Physical Control. Just as electrical pulses and heat are effective against some termites, these techniques may also work against wood boring beetles.

d. Chemical Control.

-- Borates can be painted or sprayed on wood as a barrier.

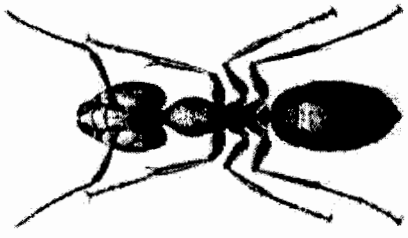
-- Insecticidal dusts can be used in wall voids, in exit holes of re-infesting beetles, or in other areas with low human activity.

-- Spot treatment with pyrethroids may sufficiently manage small infestations of re-infesting beetles.

-- Whole house fumigation is an expensive short-term treatment. It will not prevent re-infestation because there is no residual activity.

17-10. OTHER WOOD-DESTROYING INSECTS

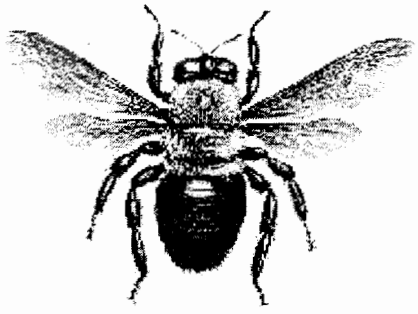
a. Carpenter Ants. Carpenter ants (Genus *Camponotus*) are so named because they tunnel into wood and excavate galleries to make the colony. They don't feed on sound wood, but excavate wood previously damaged by mechanical action, fungi, or other insects.



(1) Damage. Carpenter ants are large, sometimes over 1/2 inch long. They may build nests in the dead heartwood of living trees, logs, house timbers, poles, and almost any other wood material. They're most destructive in softwoods. Most of their tunnels are roughly parallel and run with the grain of the wood. Other shorter tunnels cut across the grain, to connecting parallel tunnels within the wood and opening to the outside.

(2) Infested Woods. These pests are normally a problem in wooden fences, posts and porch areas, but may become troublesome inside buildings. When the nest is indoors, there is usually a much larger nest in wood somewhere around the building's exterior. If carpenter ants seriously damage structural wood, it should be replaced. To control these pests, treat the nest with an appropriate insecticide.

b. Carpenter Bees. Carpenter bees belong to the Genus *Xylocopa*. They're large bees, sometimes an inch long. Most species are found in the southern U.S. and in the tropics.



(1) Activity. Carpenter bees, like carpenter ants, don't eat wood but excavate tunnels, for nesting sites parallel to the wood grain.

- Unlike ants and some other social bees, carpenter bees are solitary insects. Large numbers of carpenter bees, however, may attack the same favorable lumber.

- Tunnel openings are perfectly round or nearly so. Tunnels may extend as much as a foot and are divided into brood cells.

(2) Treatment. If these bees only occasionally excavate tunnels, this should cause no alarm to building occupants; however, repeated attacks in the same area may cause significant damage.

- Treating partly completed tunnels with appropriate pesticides will kill adult bees.
- Insecticides may be used as preventive sprays or may be packed into the tunnels, then sealed with putty.
- A simple but effective preventive treatment for use in structures is a heavy protective coat of paint.

Section II. WOOD DESTROYING FUNGI

17-11. IMPORTANCE

Wood is a fairly abundant, versatile, and relatively inexpensive building material. But unprotected wood and wood products in use and in storage are subject to the destructive effects of fire, insects, marine borers, moisture, and weathering and decaying fungi. Of all these, the single greatest cause of losses in unprotected wood is decay fungi.

- This fungal damage or decay is commonly called "dry rot," "wet rot," or "natural deterioration" and it can be prevented.
- When wood-destroying fungi are found, losses can be excessive in military storage yards and in buildings if quick action isn't taken.
- Supply and pest management personnel must be able to recognize when major wood destroying fungi are present.
- This means pest managers need a knowledge of weathering damage as a basis for comparison.

17-12. BIOLOGY

Wood destroying fungi are living organisms, plants without chlorophyll. They cannot use sunlight to produce food, so they obtain it from an organic source.

a. Spore Distribution. Fungi produce single-celled spores from which new individual plants develop.

- Most of these spores are microscopic, light in weight, resistant to extreme conditions of temperature and humidity, and readily dispersed by wind and water.
- The spores and their hyphae are easily carried from the ground and infested wood to sound wood by wood-inhabiting insects.

b. Germination and Growth. When ideal environmental conditions of humidity and temperature exist, fungal spores germinate by developing a hyphal tube or filament.

- If only water and inorganic materials are present, fungal growth will stop after the spore uses up its own available organic materials.
- If proper nutrients are available, such as the cellulose in wood, the fungus continues to grow; hyphae begin to branch out and other parts are formed, including the mycelial thallus and spore-bearing structures such as bracket fungi, toadstools, mushrooms and puffballs.

c. Physiology and Metabolism. The physiology of the fungi differs from that of green plants in that fungi, lacking chlorophyll, can't synthesize organic nutrients from dissolved inorganic materials.

- Parasitic fungi. In parasitic fungi, the mycelium penetrates living cells or the spaces between them and absorbs the intracellular or intercellular fluids of the host organisms.

- Saprophytic fungi. Most saprophytic fungi, such as those that decay wood, secrete substances that dissolve at least part of the solid organic materials fungi need to grow. The hyphae then dissolve or "digest" these materials to continue fungal growth and development.

- Most wood-rotting fungi produce an acid reaction in various types of culture media; pH values as low as 2-3 are not uncommon. Other metabolic products are also formed and, with the acids, destroy wood and other materials.

- To a lesser extent, the purely physical effects of fungal growth may also destroy useful materials.

- Mildew and mold fungi are found on many living and dead organic materials.

17-13. WEATHERING

The term "moisture damage," as commonly used, is a misnomer often applied to the damage caused by fungi and all types of weathering.

a. Causes. Weathering is most often a result of changes in moisture content, but never results solely from the moisture itself. Other factors such as frost action, abrasive effects of rain, hail, sand and dirt, and chemical changes resulting from the action of light, moisture and oxygen within the wood may contribute to weathering.

- Wood destruction can begin in storage yards where warping, twisting, and creeping may be evident.

- Warping is the result of gross dimensional changes caused by rapid, uneven moisture changes throughout the wood.

- These changes usually occur because of uneven surface exposure to wet and dry conditions and because the grain is not parallel on all surfaces.

- Another type of weathering caused by moisture changes occurs on the wood surface.

- Though wood is a hygroscopic (moisture absorbing) substance, moisture transfusion is usually a slow process.

b. The Wood Surface. When there are frequent precipitation or humidity variations, the surface layers of exposed wood swell and shrink repeatedly.

- Since most of these changes are in the outer layers of the wood, this is where alternate compressive and tensile stresses produce mechanical disintegration.

- Surface layers that undergo repeated dimensional changes develop a raised grain and become rough and corrugated or fuzzy.

- In time, superficial wood checking and splitting increases in depth and may eventually cause deep splitting.

- Most paints and varnishes are impervious to water, and when they're properly applied and maintained, they protect the wood surface against extreme, rapid changes in moisture content which produce surface weathering.

- If wood in storage or in use is to be exposed to excessive moisture changes, it should be protected by applying a water-repellent preservative.

17-14. RECOGNITION CHARACTERS FOR WOOD DESTROYING FUNGI

Fungi belong to the Division Thallophyta of the cryptogamic plants and are represented by five major classes. One of these, class Basidiomycetes, contains the order Hymenomycetales which has five families. All five of these families are represented by genera containing wood-destroying species.

- About 2000 species of wood-rotting fungi have been described, of which 200-300 commonly cause serious wood deterioration.

- Laboratory procedures are normally needed for specific identification of these fungi, but fortunately this degree of identification isn't needed to prevent the destruction they can cause.

- We can easily organize these fungi into an "artificial system of classification" based on their destructive characteristics.

- This system depends on the metabolic processes of the fungi, the composition of the materials where they grow, and their rates and methods of growth.

- By using this system, all fungi on wood may be identified as being mold fungi, stain fungi, or wood-rotting fungi.

a. Mold Fungi. These fungi can attack wood in storage or in use. They require both moisture and air within the wood. Water should make up at least 20% of the weight of the wood.

- Mold fungi in wood enzymatically break down and use only the wood starches, sugars, gums, and oils, and have no direct effect on the cellulose and lignin.

- The hyphae of most molds penetrate the wood through existing pores and pits, and usually have no direct chemical or mechanical effects upon the cell walls.

- As they remove non-structural elements of the wood, molds often reduce any natural water repellency and make the wood more subject to wetting and decay.
- Mold fungi may be found on the surface of wood which is being attacked at depth by decay fungi.

b. Stain Fungi. Stains of various types may be produced in wood by some of the deep mold fungi, and occur in shades of blues, browns, reds and yellows.

- Of all the wood stains, blue stain, or sap stain, is probably the most common and the most serious.

- In the wood rays, where food substances are concentrated, the causal fungi can seriously damage cell walls and mechanically weaken the wood.

c. Rots and Decays. These normally begin on the surface or in checks or other openings and penetrate the wood.

(1) Early stages. In early stages, the hyphae spread in all directions through the wood.

- Unlike the hyphae of mold fungi which pass from cell to cell through naturally existing holes, the hyphae of rot and decay fungi pass through "bore holes" formed in the cell walls at points of contact with the tips of growing hyphae.

- During this early stage, there is no apparent dissolution of the wood other than the microscopic "bore holes," nor is there visible change in wood characteristics other than the slight discoloration some species cause.

NOTE. It's easy to overlook this discoloration, or mistake it for color changes caused by mold fungi, chemical staining, or weathering.

(2) Advanced stages. As the decay progresses, changes in the wood become more obvious.

- In advanced stages of decay, the wood may become punky, spongy, stringy, ring-shaked, pitted, or crumbly, depending on the species of wood, type of fungus, and the extent of fungal development.

- Wood-rotting or decay fungi are usually placed in one of three major groups: the white rots, the brown rots, and the water-conducting fungi.

(3) White rots. These are caused by fungi which can enzymatically attack the ligno-cellulose complex of the cell walls, degrading the lignified material.

- Because of the slight color changes usually involved, the white-rots may at times be difficult to see.
- In areas of early attack, some have dark brown or black zone lines which may be the only visual evidence of white-rot damage.

(4) Brown rots. These are caused by decay fungi which attack the ligno-cellulose complex but cannot degrade the lignin.

- Brown rot fungi destroy cellulose but leave the lignin and some other materials as a brownish residue which, when dry, may be easily crumbled into a powder.
- The brown residue is often dry, not moist, when found, resulting in the widely used, though inappropriate term "dry rot."
- Remember, wood rotting requires the activity of wood-rotting fungi, and these organisms need at least 20% moisture in the wood to grow.
- After their initial growth, many brown-rotting fungi can develop structures highly resistant to desiccation and may survive for several years in air-dry wood, severely damaging wooden structures only occasionally exposed to moisture.
- This is why infected wood used in building construction or repair can be dangerous.

(5) Water-conducting fungi. These are brown-rot fungi which can conduct water from a single source to otherwise dry structural wood.

- The two most important species are *Merulius lacrymans* and *Poria incrassata*.
- *M. lacrymans* is the most common building decay fungus in northern Europe, and is occasionally found in the northern U.S. *P. incrassata*, commonly called the "building poria," can tolerate higher temperatures, so it's the more common of the two species.
- Initial growth may take place in cellulose material in moist soil beneath structures.
- The ability of *P. incrassata* to extend its growth over the surface of inorganic materials lets it bridge foundation walls and reach the wood above them.
- It usually first attacks unexposed surfaces and can transfer moisture to heights of more than 20 feet, so it's easy to overlook its presence before any damage is evident.

17-15. INSPECTION AND MANAGEMENT

An effective program to control decay fungi has three main phases: inspection, preventive measures, and corrective measures. Each phase entails steps designed to protect wood in storage, or in use.

a. Inspection.

(1) Inspecting wood in storage. Inspections should determine the extent of visible fungal infestations and excessive or changing moisture conditions. Look for warping, twisting, checking, and splitting. Proper pile construction and yard sanitation are essential in preventing lumber deterioration.

(2) Inspecting wood in use. Qualified personnel should make inspections at least annually for wood decay in structures; such inspections are best conducted in conjunction with termite inspections.

- Give special attention to where moisture may be present, such as in crawl spaces, basements, window and doorframes, and porch columns and railings.
- Don't overlook the fact that even heavy coats of paint may hide conditions of rot.
- Use a sharp probe to make inspections. Also, check pallets that may hold supply items, including stored food products.

b. Preventive Measures.

(1) Preventive measures for wood in storage. Stored lumber can be protected from fungus damage and the destructive effects of moisture by applying accepted principles of yard development and sanitation, pile construction, and moisture control.

(2) Preventive measures for structural wood. Structural wood often needs protection from destructive fungi.

- Control methods are based on physiological requirements and are much like those used to protect lumber in storage; however, the actual practices used to prevent decay are different.
- Preventive measures are based on using preservatives and moisture control. Preventive steps should begin while a structure is being planned and designed; however, it's never too late to make structural modifications needed to prolong the useful life of an existing building.
- When several buildings have a particular design feature that promotes fungus damage in some of them, consideration should be given to minor modifications of the others before expensive repairs are needed.
- Proper design begins at or below the ground level; for example, having drainage flow away from the structure.
  - -- Some buildings collect drain water underneath, and this situation needs correcting for protection.
  - -- In some cases, even with adequate drainage, condensation on the sills, joists and sub-flooring of basement-less buildings may be severe enough to cause rapid deterioration.

(3) Crawl spaces. It's important to maintain ventilation in crawl spaces under buildings.

- The "2 plus 1/3" formula". The following formula for ventilation is normally adequate if no pockets of stationary air are permitted in corners or behind interior foundation walls. It's called the "2 plus 1/3" formula.
  - -- It requires crawl space vent openings to have a net unobstructed area equal to 2 square feet for each 100 linear feet of outside wall plus 1/3 square foot for each 100 square feet of crawl space area.
  - -- Obstructions require larger openings.
  - -- If the gross area is partially covered by bars, grills, or grids, vent size should be adjusted to give an adequate net area.
  - -- If vents are closed during cold weather to reduce fuel costs, this may have only short-term benefits.

  In the long term, maintenance costs may increase and the building's useful life may be reduced because this action increases the potential for attack by wood-destroying fungi.
- Soil cover with asphalt roll roofing. If the cost of comfortably heating buildings while ensuring adequate crawl space ventilation seems prohibitive, another condensation-prevention technique may be desirable. A proven method involves applying a soil cover using asphalt roll roofing. No lapping, fastening, cementing, or preliminary leveling is needed.
- Plastic films. Plastic films are also effective. They're easier to handle but must be weighted at the corners.

(4) Siding and trim. Most serious decay in siding and exterior trim is found on buildings having little or no roof overhang or with faulty eaves, gutters, or down spouts.

- Water may run down the sides and seep into joints, particularly butted joints between siding pieces and between siding or trim. It's nearly impossible to maintain sufficiently tight joints to exclude seepage water during severe rain washings, and paint isn't a dependable joint sealant.

- Protecting sapwood. In many areas, sidings and trim are made of sapwood which can be protected by providing:

  -- Good projection of eaves and rake of gables.

  -- Tight joints and well-maintained paint surfaces.

  -- Lightweight, vapor-permeable (breathing) building papers under siding to speed drying of any seepage water.

  -- Sound flashing on exposed doors, windows or other openings, and any horizontal projections.

  -- Eaves, gutters and down spouts.

If rain washing can't be prevented, preservatives should be used.

(5) Building appendages. Wooden porches and exterior steps, even of the best design and construction, are decay hazards, and any feature promoting seepage will hasten decay. If steps and stoop rails are protected by well-maintained painted surfaces, they're much less susceptible to decay.

- Considerable protection may be provided by extending the rail over the top of the newel rather than abutting the end of the rail to the side of the post.

- Rail splices over a post greatly increase decay potential. Consider these design features during inspections and when replacement is needed.

- The common practice of placing trim over the ends of drop siding doesn't normally increase decay potential, but does allow less water seepage than the common butt joints of siding to trim.

- With bevel siding, placement of trim over the siding ends tends to reduce wetting, but not to any great degree. The bevel results in a long vertical opening and allows water to easily flow back under the siding. With bevel siding, metal corners are the only structural means to reduce water seepage; all other types of corner joints leak badly.

c. Corrective Controls.

(1) Corrective controls for protecting wood in storage. Fungus-infested wood in storage should be separated from clean lumber. In no case should it be allowed to remain untreated in a lumber yard.

(2) Corrective controls for protecting wood in use. Seriously rotted wood can only weaken the structure; such wood should be replaced. Lightly damaged wood may be at least protected by using preservatives. Don't try to "pressure treat" wood in use by applying fungicides or insecticides under pressure to drilled holes. Deep penetration is possible by making surface applications of grease or emulsion formulations. To control water-conducting fungi, give special attention to the moisture source. Use of water-soluble fungicides may be advisable in some cases, but it's rarely necessary to use wood preservatives at all points where these fungi conduct moisture.

EXERCISES, LESSON 17

REQUIREMENT. Answer the following questions by completing the incomplete statement or by writing the answer in the space provided at the end of the question. After you have completed all the exercises, turn to the Appendix and check your answers.

1. Why is the name "powder post beetles" appropriate for these insects? _____
_____
_____.

2. In nature, roundheaded wood borers play an important role. What is this role? _____
_____
_____.

3. _____, found in moist wood, cause damage to pilings and decks under wharves and boardwalks along the seashore. The treatment to such damaged wood is _____
_____
_____.

4. A simple but effective treatment to prevent the intrusion of carpenter bees that make tunnels in wood is _____
_____.

5. Wood destroying fungi are carried from the ground and infested wood to sound wood by _____
_____
.

6. Water-conducting fungi can begin in unexposed surfaces and then transfer moisture to height of more than ___ feet.

7. If it is economically unsound to use the "2 plus 1/3 formula" to maintain adequate ventilation in buildings, moisture can be reduced with _____
_____ and _____
.

8. When you are inspecting wood in storage, look for _____, _____,
_____, and _____.

9. What happens to surface layers of wood that undergo repeated dimensional changes?
_____
_____
_____.

10. What kind of damage can occur in a building in which wood infested with Ivory Marked beetles is used? _____
_____
_____
.

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APPENDIX A: SOLUTIONS TO EXERCISES

SOLUTIONS TO EXERCISES, LESSON 1

1. Mosquito-borne diseases include malaria, dengue, yellow fever, encephalitis, and filariasis.

2. a. The mosquito's use of atmospheric oxygen for respiration.
   b. The mosquito's use of water-borne particles as food.

3. The mosquito rests quietly on the water surface while transforming to the adult stage.

4. a. Flower nectar.
   b. Vertebrate blood.

5. About one city block to 20 miles.

6. a. In large permanent bodies of fresh water.
   b. After dark and again just before daylight.

7. *Culex.*

8. Because, after hatching, the larvae descend below the water surface and insert their air tubes into the stems or roots of aquatic plants.

9. *Othopodomyia.*

10. *Dienocerite.*

SOLUTIONS TO EXERCISES, LESSON 2

1. a. Determine the mosquito species present.
   b. Determine the abundance of mosquitoes.
   c. Determine their potential as disease vectors.
   d. Collect enough information on which to base a pest management program.

2. Larval surveys show the exact areas where mosquitoes are developing. When these areas are known, mosquito management operations can be planned accordingly.

3. Some species are poorly or not attracted to light.

4. a. 1 to 4.
   b. From dusk to dawn.

5. Average the weekly mosquito index for several stations.

6. Animal bait stations.

7. Controlling the water where mosquitoes develop.

8. a. Improve natural draining.
   b. Stream flushing.
   c. Impound water.

9. a. Soil erosion.
   b. Effects on fish.
   c. Effects on wildlife.

10. a. Larvicides.
    b. Adulticides.

SOLUTIONS TO EXERCISES, LESSON 3

1. a. African sleeping sickness.
   b. Onchocerciasis.
   c. Leishmaniasis.

2. They are blood feeders.

3. The stable fly has a sharp, piercing, forward projecting, nonretractile proboscis.

4. Onchocerciasis.

5. Sand flies are recognized by the position of their wings, which are elevated and spread to form a "V."

6. a. Tropical Africa south of the Tropic of Cancer.
   b. 20 miles per hour.

7. African sleeping sickness.

8. Their vicious biting habits.

9. a. Dysentery.
   b. Cholera.
   c. Typhoid fever.

10. a. Close association with people.
    b. Abundance of flies.
    c. Ability of the flies to transmit disease.

SOLUTIONS TO EXERCISES, LESSON 4

1. Conduct surveys to identify suitable development sites so that we can take corrective measures.

2. Developing a list of all potential filth fly infestation sites.

3. Measures for a successful fly control program.

4. The procedure:

- Places a grill over an attractant.
- The operator counts the number of flies landing on the grill or a portion of the grill in a given time period (usually 1 minute.)

5. A screen cage with a funnel type entrance which may be placed over a bait selected to attract several species of domestic flies.

6. a. Place the fly trap in the same location each day.
   b. Use the same bait each day.

7. Between interior rooms rather than in an outside doorway.

8. a. Space sprays have no lasting effect.
   b. Frequent re-treatment is necessary.

9. a. Find and remove larval development sites.
   b. Improve sanitation.
   c. Take steps to exclude flies from the building/area.

10. a. Find the source of fly infestation.
    b. Correct the conditions which contribute to fly infestation.

SOLUTIONS TO EXERCISES, LESSON 5

1. The cost of managing cockroaches in all types of structures.

2. Most cockroaches living in structures are omnivorous; other species are herbivorous.

3. a. An ootheca is a purse-shaped egg case containing two rows of eggs.

   b. Gradual metamorphosis.

4. a. Under tree bark.
   b. In sewers.
   c. In underground utility chases.

5. Because gravid females spend more time in harborage than other life stages.

6. Brown-banded.

7. Asian.

8. Their abdomens are curled up when they move around.

9. The female has rudmentary wings, and the wings of the male cover the entire abdomen.

10. Wood.

SOLUTIONS TO EXERCISES, LESSON 6

1. a. List facilities that receive sanitation inspections.
   b. Select the methods and frequency for sampling cockroach populations.

   c. Initiate collection of cockroaches and evaluation of facilities for conditions that are conducive to cockroach infestations.

2. Use live traps when live cockroach specimens are required for resistance testing or when sticky traps are not available.

3. a. Difficult to coordinate and arrange.
   b. Very time consuming.

4. German cockroaches are attracted to corrugated cardboard for ideal harborage and they eat the glue.

5. a. German cockroaches.
   b. Brown-banded cockroaches.

6. a. Eliminating harborages reduces the size of the cockroach population the structure can support.
   b. Eliminating harborages makes chemical control actions more effective.

7. Boric acid acts as a stomach poison ingested when cockroaches groom. The boric acid abrades the cockroach's cuticle on contact, causing dehydration and death.

8. Such treatments do not leave surface deposits which might come in contact with food.

9. A bait station or dust.

10. As a survey tool.

SOLUTIONS TO EXERCISES, LESSON 7

1. Can't or won't bathe or wash clothing regularly.

2. a. Epidemic typhus.
   b. Relapsing fever.

3. Crab.

4. The back of the neck and behind the ears.

5. Medical personnel.

6. a. Murine typhus.
   b. Bubonic plague.

7. a. Irritation.
   b. Loss of blood.
   c. Extreme discomfort.

8. a. Tapeworms.
   b. Dermatitis; allergy.

9. If the rodent dies first, fleas will leave it and move on to another host.

10. When there is an animal in the trap, take the trap to a processing area. Anesthetize the animal, and comb it with a fine-toothed comb over a large white enameled pan to collect specimens.

SOLUTIONS TO EXERCISES, LESSON 8

1. Scrub typhus.

2. An asthma-like.

3. Under the epidermal skin layer of humans.

4. The management technique is chemical control. Residual spray should be applied shortly before the troops occupy the area.

5. Modifying buildings so birds cannot enter.

6. You are correct if you listed any four of the following:

   - Lyme disease
   - Tick-borne typhus
   - Tularemia
   - Relapsing fever
   - Tick-borne encephalitides
   - Hemorrhagic fevers
   - Tick paralysis
   - Human ehrlichiosis

7. Tick-borne typhus, ehrlichiosis, and Tularemia.
   Silver spot at the tip of the scutum.

8. American dog tick.

9. Rash and fever.
   Debilitating arthritis.

10. a. Avoid known tick infested areas, when possible.
    b. Perform area vegetation management.
    c. Use residual pesticide treatments.

SOLUTIONS TO EXERCISES, LESSON 9

1. a. Food pests.
   v. Animal fiber pests.
   c. Wood products pests.

2. Unprotected products made in whole or part of hides, wool, mohair, fur, hair, feathers, down, or animal bristles.

3. Wood product.

4. Rice.

5. A single warehouse Dermestid beetle larva has thousands of barbed setae covering its body. The setae break off and contaminate the food the larva is in. What that contaminated food is eaten, the setae enter the individual's intestinal lining causing dysentery and diarrhea.

6. U.S. Army Veterinary Corps.
   U.S. Air Force Military Public Health Officers.

7. You are correct if you listed any four of the following:

   - Sodium vapor lights outside, indirectly placed.
   - Vegetation around warehouse at least two to three feet away from the structure.
   - Vegetation must be of the type that does not attract insects.
   - Clean and sanitary storage areas.
   - Use of insect proof containers such as metal, glass, multi-wall paper bags with tight end closures.
   - Appropriate temperature in storage area.
   - Appropriate use of insecticidal treatments (residual sprays, space treatments, and fumigants).

8. Sex attractants.
   An alarm system.

9. a. Many products must be shipped overseas; goods in transit can become infected with pests.
   b. The military must store great quantities of infestible products for long periods of time, often in poor environmental conditions.

10. Pheromones cannot be removed from flour.

SOLUTIONS TO EXERCISES, LESSON 10

1. a. The separation of the abdomen into two distinct regions: the pedistel and the gaster.
   b. The elbowed antenna.

2. a. Males.
   b. Queens.
   c. Females.

3. Fire ants.

4. Harvester ants.

5. Carpenter ants.

6. a. Collecting by jar.
   b. Collecting by brush.
   c. Collecting by digging into the nest.

7. In a ring around the fire ant mound and in accordance with the instructions on the label.

8. Sanitation.

9. Chagas'.

10. a. Anemia.
    b. Stunted human development.
    c. Wasting of the body.

11. Residual sprays applied as crack and crevice treatment.

12. Silverfish prefer high carbohydrate foods such as flour and oatmeal, but they will eat glues, paper, rayon fabrics, etc. Firebrats prefer paper and paper products.

SOLUTIONS TO EXERCISES, LESSON 11

1. a. Bite.
   b. String.
   c. Contact.

2. a. Honey producers.
   b. Plant pollinaters.

3. Through Texas from Mexico in 1990.

4. Hive disturbance.

5. Fiddle-shaped marking.

6. Avoidance.

7. The temperature of snakes varies with the temperature of their surroundings.

8. Triangular.
   Eliptical.

9. To look at the color pattern. A coral snake has a bright collor pattern of red, yellow, and black bands with the red and yellow bands always touching.

10. Immobilize the limb where the bite occurred and transport the victim to the nearet medical facility. If it takes more than 30 minutes to get to a medical facility, place ice-filled towels around the bite site and constricting bands 2 finger widths above and below the bite.

SOLUTIONS TO EXERCISES, LESSON 12

1. a. Noise nuisance.
   b. Fecal contamination of walkways, roads, vehicles.
   c. Source of disease and ectoparasites.
   d. Damage to real property such as airplanes, and associated safety issues.

2. A fungus in soil contaminated by pigeon droppings.

3. Yes.

4. The gulls eat and loaf in fields near runways. Plans taking off and landing may collide with the gulls, the result being serious accidents.

5. Yes.

6. Nesting.

7. a. Small canon.
   b. Large vibrators.
   c. Recorded distress calls.
   d. Firecrackers/crackershells.

8. Bats carry rabies.

9. a. Moth balls.
   b. Moth flakes.

10. Wood.
    Oakum.
    Metal.
    Concrete.

SOLUTIONS TO EXERCISES, LESSON 13

1. 3, 2.

2. Their tooth enamel.

3. They are very suspicious of any new objects or foods in their surroundings.

4. Rodents live so close to people that rodents do not fear human odor.

5. Side illumination.

6. Sanitation.

7. Rodents do not seem to associate their loss of strength with their food supply.

8. The traps are completely camouflaged except for the rat entrance.

9. 4th, 9th.

10. Ectoparasites are links in transmitting many rodent-borne diseases to people.

SOLUTIONS TO EXERCISES, LESSON 14

1. Military equipment.
   Supplies.

2. Poisoning.

3. You are correct if you listed any two of the following:

   - Extent of burrow system.
   - Chance for leakage.
   - Closeness of man runs to the surface.
   - Gophers can plug off burrows to escape poisonous gas.

4. a. Plague.
   b. Tularemia.

5. Tree squirrels.

6. Their burrowing can cause airstrips and bunkers to collapse.

7. Hares and rabbits have four upper incisor teeth; rodents have two upper incisor teeth.

8. a. Tularemia.
   b. Spotted fever.
   c. Plague.

9. Rabies.

10. The installation medical authority.

SOLUTIONS TO EXERCISES, LESSON 15

1. a. Destroy structures or materials people use.
   b. Assist in the conversion of dead trees and other plant products to substances that can be used by plants.

2. Antennae. Termites - elbowed.
   Ants - not elbowed.

   Wings. Termites - over the abdomen.
   Ants - above the body.

3. New termite colonies form when existing termite colonies become overcrowded. New colonies usually form in the fall or spring, depending on the termite species.

4. a. Workers maintain and feed the colony, damaging wood in obtaining food.
   b. Soldiers protect the colony.

5. a. Obtain food.
   b. Shield against predators.
   c. Shield against unfavorable environment.

6. Above 50 to 60°F.

7. Subterranean.

8. Dampwood.

9. Formosan.

10. Drywood.

SOLUTIONS TO EXERCISES, LESSON 16

1. a. Inspection.
   b. Preventive control.
   c. Corrective control measures.

2. Wood debris is left in the soil at the building site.

3. A large termite colony and considerable termite damage.

4. Termite damage.

5. 4" reinforced concrete.

6. 18.

7. a. Electricity.
   b. Heat treatment.

8. a. Digging out termite colonies.
   b. Breaking open termite tubes.

9. a. Expensive.
   b. Hazardous.
   c. No residual effect.

10. ♦ Drill holes through the foundation wall beneath the slab.
    ♦ Drive a long, perforated pipe (pointed at the end) between the slab and the soil.
    ♦ Pump insecticide through the rod (under pressure) as the rod is withdrawn.

SOLUTIONS TO EXERCISES, LESSON 17

1. The name is appropriate because these beetles can reduce wood to finely powdered frass.

2. Their chief role in nature is to destroy dead trees to permit new growth.

3. Wharf borers; To replace the wood.

4. A heavy coat of paint.

5. Insects that live in wood.

6. 20.

7. Soil cover with asphalt roll roofing.
   Plastic film.

8. Warping.
   Twisting.
   Checking.
   Splitting.

9. The wood develops a raised grain and becomes rough and corrugated or fuzzy.

10. The damage spreads because beetles may emerge from floor to furniture years after the infested wood is used.

APPENDIX B: ILLUSTRATION REFERENCES

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